TM 9222

378

TM 9222

Dual Trace Unit

INSTRUCTION MANUAL

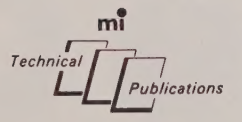
mi
MARCONI INSTRUMENTS

MP MASTER
MA23736

378

Instruction Manual
No. EBM 9222
for

Dual Trace Unit
TM 9222



©
1968

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

C.P. 2c
7/68/A

EBM 9222
1 - 7/68

Contents

Chapter 1 GENERAL INFORMATION

1.1 Features 3
1.2 Data summary 3

Chapter 2 OPERATION

2.1 Preparation for use 6
2.2 First time operation.. 6
2.3 Controls 6
2.4 Connection in cascade 7
2.5 Triggering and display 7
2.6 Effects of trigger source on dual trace displays 8
2.7 Alternate display and mixed trigger . 8
2.8 Polarity balance 9

Chapter 3 TECHNICAL DESCRIPTION

3.1 General 10
3.2 Basic system 10
3.3 Circuit analysis 12
Input attenuators (A21) 12
Cathode followers (A22) 12
Cathode follower protection circuit.. 12
Phase splitter (A23, A24) 13
x1/x10 gain switching (A23, A24) ... 13
x10 amplifier (A23, A24) 14
Buffer stage (A23, A24) 14
Signal gate driver (A25) 14
Gain balance 14
Position control (A25) 14
Signal gates (A25) 15
Trigger pick-off amplifier (A25) ... 15
Trigger selection gates (A25) ... 15
Trigger source amplifier (A25) ... 15
Channel 1 output stage (A25). ... 15
Delay line driver stage (A25) ... 16
Delay line (A25) 16
Main amplifier (A26) 16
Output stage (A26) 17
Supply line filters 17
Channel switch driver (A25).. ... 17
Trace separation drive (A25). ... 17

Chapter 4 MAINTENANCE

4.1 Introduction 18
4.2 Screw fasteners 18
4.3 Location of sub-assemblies 18
4.4 Access to sub-assemblies 18
Annotated layout illustrations ... 19
4.5 Test points 20

Chapter 5 REPAIR

5.1 Introduction 21
5.2 Component location... 21
5.3 Replacement of components.. ... 21

Index to Units 25

Chapter 6 REPLACEABLE PARTS

Introduction and ordering... 26
Parts lists - (see Index on page 25) ...

Chapter 7 CIRCUIT DIAGRAMS

Circuit notes 36

Fig.
7.1 Input cathode followers 37
7.2 Channel 1 input amplifier and channel 2 input amplifier 39
7.3 Beam switch and trigger 41
7.4 Main amplifier 43
7.5 Vertical amplifier interconnection 45

Chapter 1

General information

1.1 FEATURES

TM 9222 is a dual trace vertical amplifier plug-in unit for use with Marconi Instruments Oscilloscope TF 2210 and has a bandwidth of 100 MHz and a sensitivity of 5 mV/cm up to 75 MHz. A further increase of sensitivity can be arranged by cascading channel 1 with channel 2, which provides an overall sensitivity of 500 μV/cm on a single trace. A calibration position on the attenuator is provided for standardizing the gain of the unit.

Separate triggering from either channel, or from both channels in the mixed mode, can be selected.

Each channel has a front panel connector providing power supplies for FET probes.

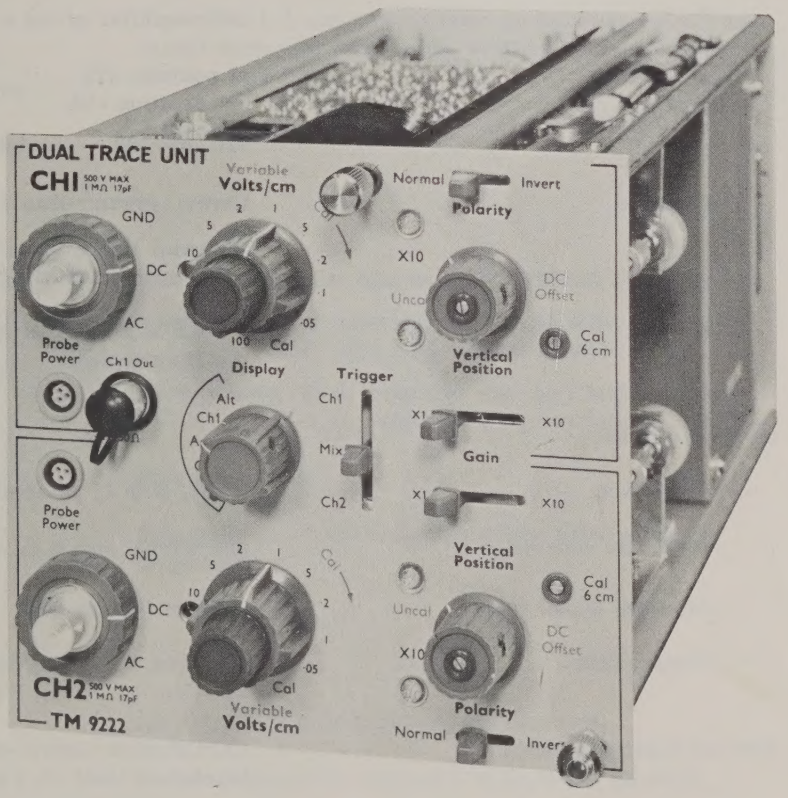


Fig. 1.1 Oscilloscope TF 2210 with dual trace plug-in unit

1.2 DATA SUMMARY

3 dB bandwidth

D. C. coupled input: x1 (50 mV/cm) d. c. to 100 MHz.
x10 (5 mV/cm) d. c. to 75 MHz.

A. C. coupled input: x1 (50 mV/cm) 4 Hz to 100 MHz.
x10 (5 mV/cm) 4 Hz to 75 MHz.

L. F. response extended to 0.4 Hz when used with TM 8561 probe switched to x10.

Pulse response:

With the switched gain control at x1, the rise time is better than 3.5 ns for an overshoot of not greater than 5% for any position of the VARIABLE V/CM, POLARITY and VERTICAL POSITION controls.

With the switched gain control at x10, the rise time is better than 4.7 ns for an overshoot of not greater than 5% for any position of the VARIABLE V/CM, POLARITY and VERTICAL POSITION controls.

Sensitivity:

Ranges: Eleven switched ranges in 1-2-5 sequence from 50 mV/cm to 100 V/cm. A twelfth position (CAL) on the attenuator switch permits gain standardization by screwdriver adjustment of a preset control.

x10 magnifier giving a sensitivity of 5 mV/cm to 10 V/cm.

Accuracy: x1 position ±3%
x10 position ±3% using internal calibrator

x10 gain ±3% internally set

Variable: Cover: greater than 2.5:1.

Indicator lamps show when the unit is being operated in uncalibrated and x10 gain conditions.

Window: ±30 cm at all sensitivities. (In calibrated positions at low frequencies.)

Input conditions

Impedance: 1 MΩ, with 17 pF in shunt, at all sensitivities.

Maximum voltage: 500 V combined d.c. and a.c. peak.

Apparent signal delay: Greater than 40 ns.

Power socket: Provides for connection to a FET probe, (i.e. Tektronic P6045).

Vertical position range: Uncalibrated control enables the display to be moved through at least 16.0 cm.

D.C. offset: ±0.15 V at all sensitivities. (Screwdriver adjustment.)

Polarity inversion: Signals on channel 1 and channel 2 may be inverted independently.

Vertical display modes:

Alternate: Display alternates between channel 1 and channel 2.

Channel 1: Channel 1 only.

Add: Algebraic sum of channel 1 and channel 2 (i.e. ± channel 1 ± channel 2).

Channel 2:	Channel 2 only.
Chop:	Chop repetition rate approximately 1 MHz.
Trigger selection for time base:	Channel 1 only. Mixed. Channel 2 only.
Breakthrough	
Common mode:	x1 gain breakthrough <20 dB at 100 MHz. x10 gain breakthrough <20 dB at 75 MHz.
Socket-to-socket:	Breakthrough <70 dB at 100 MHz.
Gate:	Breakthrough <35 dB at 100 MHz.
Vertical linearity:	Less than 1.5 mm compression or expansion of a 2 cm signal when positioned to the vertical extremes of the display area.
Time difference between channels:	Less than 1 ns.
Channel 1 output:	
3 dB bandwidth:	Switched internally (normally in NARROW position). Wide band: D.C. coupled; d.c. to 15 MHz. A.C. coupled; 4 Hz to 15 MHz. Narrow band: D.C. coupled; d.c. to 1 MHz ±0.3 MHz. A.C. coupled; 4 Hz to 1 MHz ±0.3 MHz.
Output impedance:	Nominally 50 Ω.
Gain:	Nominally x1 or x10 according to the position of the magnifier.
Channel 1 and channel 2 in cascade	
Sensitivity:	Maximum sensitivity 500 μV/cm (nominal).
Bandwidth:	Switched internally (normally in NARROW position). Wide band: D.C. coupled; d.c. to 15 MHz. A.C. coupled; 4 Hz to 15 MHz. Narrow band: D.C. coupled; d.c. to 1 MHz ±0.3 MHz. A.C. coupled; 4 Hz to 1 MHz ±0.3 MHz.
Noise:	Less than 3.5 mm at maximum sensitivity (500 μV/cm; minimum bandwidth).

Dimensions and weight

Height	*Width*	*Depth*	*Weight*
$5\frac{1}{2}$ in (140 mm)	$5\frac{1}{2}$ in (140 mm)	14 in (356 mm)	8 lbs (3.6 kg)

Chapter 2

Operation

2.1 PREPARATION FOR USE

Insert the dual trace unit in the left-hand compartment of the TF 2210 oscilloscope and tighten the fixing screw near the top of the front panel.

2.2 FIRST TIME OPERATION

If you are unfamiliar with the operation of the oscilloscope and/or the dual trace unit, see the 'first time operation' section in the TF 2210 manual.

2.3 CONTROLS

The functions of the controls and connectors on the front panel of the dual trace unit are detailed in this section. The controls (1) to (8) are identical for each channel.

① Input socket: BNC socket concentric with ②, maximum input is 500 V combined d. c. and a. c. peak.

② GNC-DC-AC: Using this switch the input may be a. c. or d. c. coupled to the amplifier or the input socket open circuited while the amplifier input is earthed.

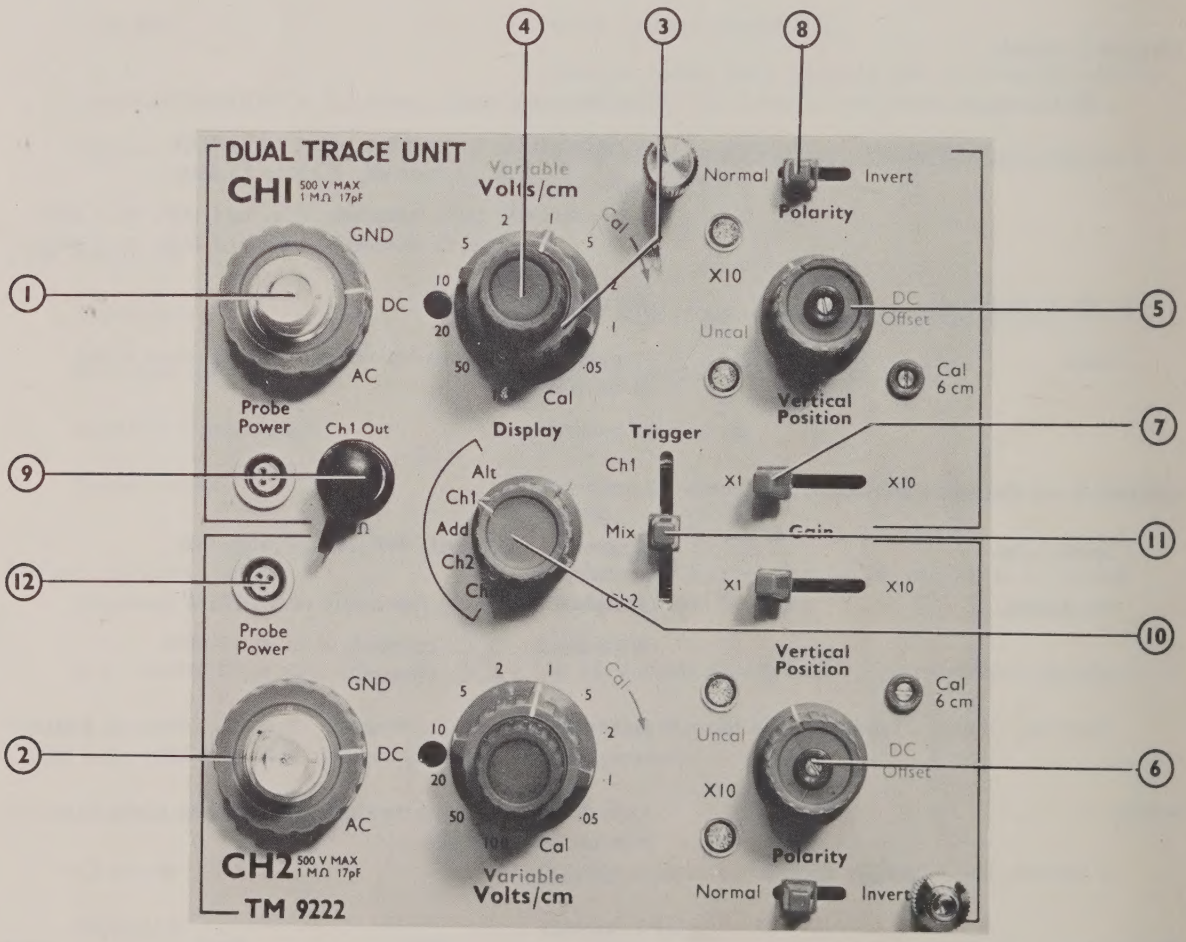


Fig. 2.1 Front panel controls

③ VOLTS/CM: This controls the vertical deflection sensitivity by means of a switched attenuator. The CAL position is valid only when the VARIABLE VOLTS/CM control is in the calibrated position, i.e. fully clockwise. When the switch and the control are in the CAL position a square wave, 6 cm in height, will be displayed on the screen. The amplitude of the square wave may be corrected or adjusted by means of the CAL 6 cm preset on the front panel.

④ VARIABLE VOLTS/CM: This control varies the amplitude of the trace by at least 2.5:1 on each position of VOLTS/CM switch.

⑤ VERTICAL POSITION: This control moves the trace vertically so that the trace can be centred on the screen. The trace may be moved ±8 cm vertically from centre.

⑥ D.C. OFFSET: This preset, concentric with the VERTICAL POSITION control offsets d.c. inputs by approximately ±3 cm on the x1 GAIN position and ±30 cm on the x10 GAIN position.

⑦ x1-x10 GAIN: The sensitivity of the dual trace unit is changed by this switch from a maximum of 5 mV/cm in the x10 position to 50 mV/cm in the x1 position.

⑧ POLARITY: This switch allows inversion of the polarity irrespective of other control positions.

⑨ CH1 OUTput: Provides a 50 Ω output from the channel 1 amplifier. The gain between the CH1 input and CH1 OUTput sockets is determined by the setting of the x1-x10 GAIN switch. See Sect. 2.4.

⑩ DISPLAY switch: This can provide single operation of channel 1 or channel 2 alone. In the ADD position the two channels are added and differential measurements may be obtained by inverting one of the channels. Dual trace facilities are obtained in either the alternate mode or the chop mode. The chop repetition rate is approximately 1 MHz and is useful for low frequency signal measurements.

⑪ TRIGGER switch: Can provide separate triggering from either channel or, in its central position, from both channels mixed. See Sect. 2.5.

⑫ POWER PROBE sockets: These provide power for a FET probe giving a high input impedance and low input capacitance. This is particularly useful when the full sensitivity of the oscilloscope is required for making measurements in circuits where a negligible load is desirable.

2.4 CONNECTION IN CASCADE

By using the CH1 OUTput socket, a cascade connection between channel 1 and channel 2 can be made and, with the GAIN of each channel switched to x10, the overall sensitivity at CH1 input is 500 μV/cm.

The bandwidth is nominally 15 MHz but is usually reduced, to minimize noise level, by an internal switch to a nominal 1 MHz. The switch is accessible by withdrawing the dual trace unit or by removing the left-hand side panel of the oscilloscope.

2.5 TRIGGERING AND DISPLAY

When the triggering is in the mixed mode, the trigger signal is affected by channel switching, polarity and vertical position adjustments, but in the channel 1 or channel 2 triggering modes this is avoided.

Signals from each channel may be displayed on the screen sequentially. Fig. 2.2 shows the effect of feeding a square wave into channel 1 and a saw-tooth waveform into channel 2, with the essential controls for this display as follows:

Dual trace unit:	DISPLAY switch - ALTernate Other controls as required. CH1 VERTICAL POSITION control should be adjusted to place the CH1 display in the top half of the screen and CH2 POSITION control adjusted to place CH2 display in the lower half of the screen.
'A' Sweep unit:	DISPLAY switch - ALTernate DELAY switch - OFF SWEEP switch - NORM

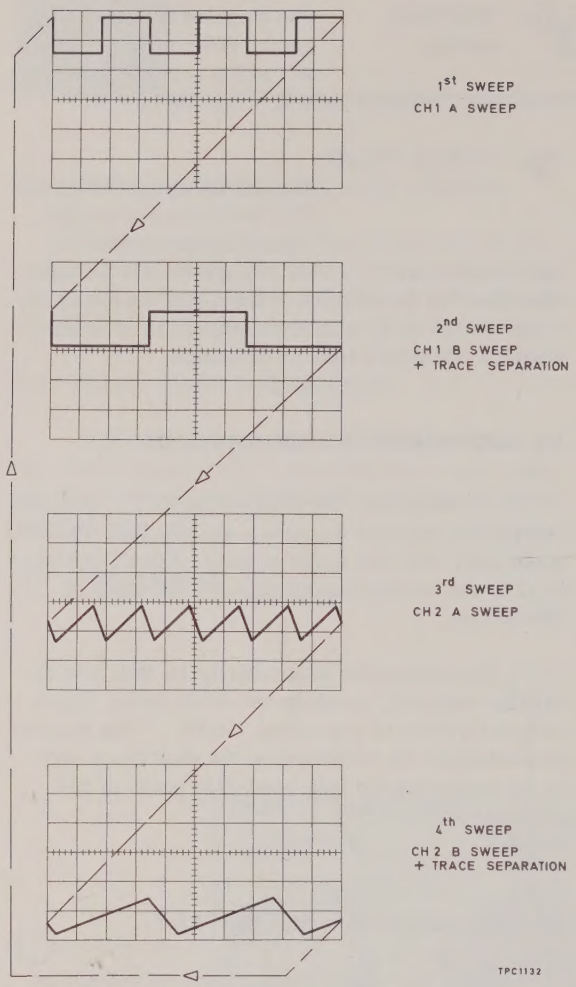


Fig. 2.2 Four traces appear sequentially on the screen and the display is formed as shown, the dotted line indicating the flyback path. Except at low sweep speeds the four sweeps are visible at the same time on the c.r.t.

Main frame unit: TRACE SEPARATION - adjusted as necessary to separate the 'A' and 'B' sweeps.

Using the delay mode, the traces shown will have brightened portions on the A sweep or delaying sweep, and the B sweep, or delayed sweep, will be the corresponding bright portion expanded to full trace width. This function is described in the TF 2210 manual, Sect. 2.5.

2.6 EFFECTS OF TRIGGER SOURCE ON DUAL TRACE DISPLAYS

Three trigger sources are provided in the dual trace unit: channel 1, mixed and channel 2.

The CH1 and CH2 positions of the TRIGGER switch give a source of trigger signal taken from each channel before the DISPLAY switch circuit. These sources are therefore unaffected by any channel switching or by the POLARITY or POSITION controls.

The MIX position of the TRIGGER switch provides trigger signals from a point after the DISPLAY switch circuit. This source is clearly affected by channel switching and the POLARITY and POSITION controls. The trigger source is changed with the signal on dual trace mode.

2.7 ALTERNATE DISPLAY AND MIXED TRIGGER

This position is useful if two non-synchronous signals are to be displayed simultaneously. So long as the two signals overlap in the vertical direction by 2 mm or more d.c., a.c. or auto triggering can be used.

If the VERTICAL POSITION controls are adjusted so that there is no overlap, then no sweep will occur with d.c. triggering, and a jittery dim trace will probably occur with a.c. or automatic triggering especially if the sweep rate is fast.

The reason for this behaviour is illustrated in Fig. 2.3. The first sequence shows the events with d.c. triggering. Here the sine wave on channel 1 triggers the sweep, the sweep changing the trigger source during retrace and selecting the square wave from channel 2. The d.c. component of the channel 2 signal is such that at no time does the signal come within the triggering threshold indicated by the dashed horizontal lines. Therefore the sweep will run once displaying channel 1 and then stop.

The second sequence shows what happens on the a.c. and automatic positions.

As before, the sine wave on channel 1 triggers the sweep and the channel switch changes over during the retrace period. However, as the circuit is now a.c. coupled with a time constant of 18 ms, gradually the triggering signal will decay back to the trigger level setting. Thus, instead of not being triggered at all, the sweep is now triggered at about a 50 Hz repetition rate. At slow and medium sweep speeds this may be tolerable but on fast sweeps this gives rise to dim and jittery displays.

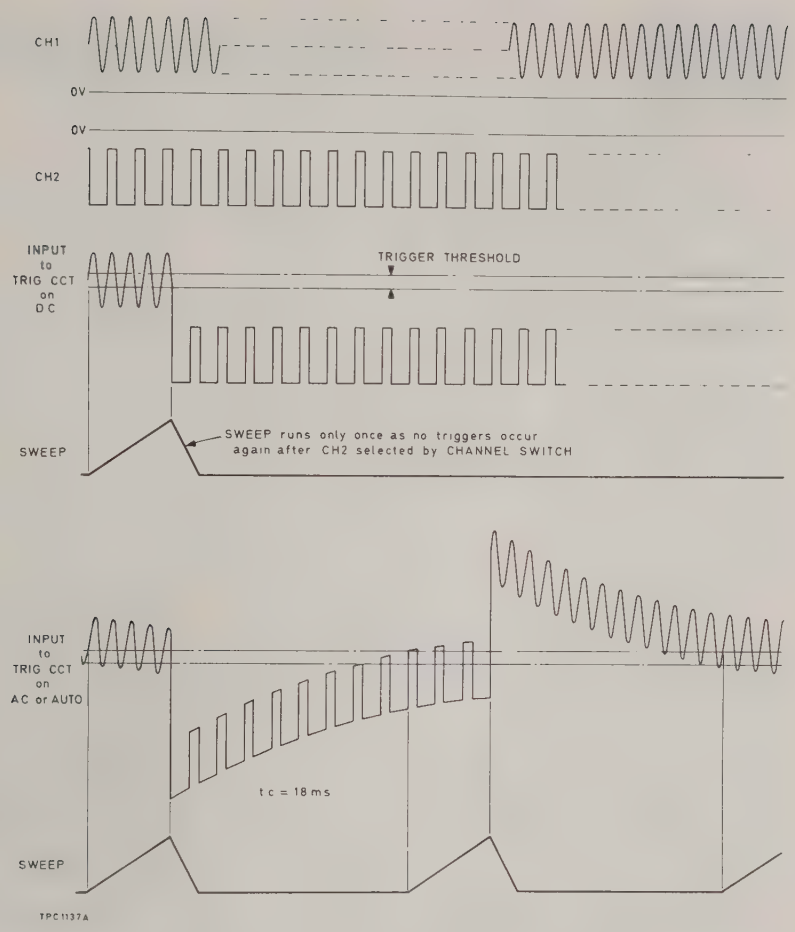


Fig. 2.3 Behaviour of the triggering in a mixed trigger

The MIX position of the trigger switch can be a most useful position for certain display problems using alternate display mode, but it is normally best to use channel 1 or channel 2 as a trigger source for general purpose work.

2.8 POLARITY BALANCE

Set the controls on the front panel of the oscilloscope as detailed in Sect. 4.5 of EB 2210. Allow at least 10 minutes warm-up before making any adjustment described below.

Centre the trace in the middle of the screen. Operate the POLARITY control and note the magnitude and direction of trace movement. Ideally the trace should not move with operation of this switch. Using a screwdriver, adjust the preset DC OFFSET (concentric with the POSITION control) so that there is no trace movement in the vertical direction when operating the POLARITY switch.

Chapter 3

Technical description

This chapter gives detailed system and circuit information about the dual trace unit. Where necessary the description is related to Oscilloscope TF 2210.

3.1 GENERAL

This unit has been designed to plug into Oscilloscope TF 2210. Connections to the circuits on the TF 2210 main frame are made via a 36-way connector and the high frequency signals to the c.r.t. deflection plates via two BNC connectors.

3.2 BASIC SYSTEM

This section is divided into three parts as follows: (i) signal path, (ii) trigger circuits and (iii) dual trace unit connections and trace separation.

(i) Signal path

The diagram shows the basic signal path through the dual trace unit. Since channel 1 and channel 2 are almost identical the following description of the signal path through channel 1 also applies generally to channel 2.

Considering channel 1 amplifier, the signal goes via the input socket through either a capacitor for a.c. coupling or directly to the attenuator. In the GND position the input to the amplifier will be short circuited whilst the input to the oscilloscope is open circuited.

The attenuator is a twelve position turret type providing a stepped range from 50 mV/cm to 100 V/cm in the x1 GAIN position. From the attenuator the signal passes to one of two cathode followers and then to the input amplifier of which the first stage is a phase splitter. The other cathode follower supplies the other side of the phase splitter with the d.c. offset voltage. The output of the attenuator may be replaced by the calibrator signal; this is a 1 kHz square wave which provides a display of 6 cm when the stepped attenuator is in its twelfth or CAL position.

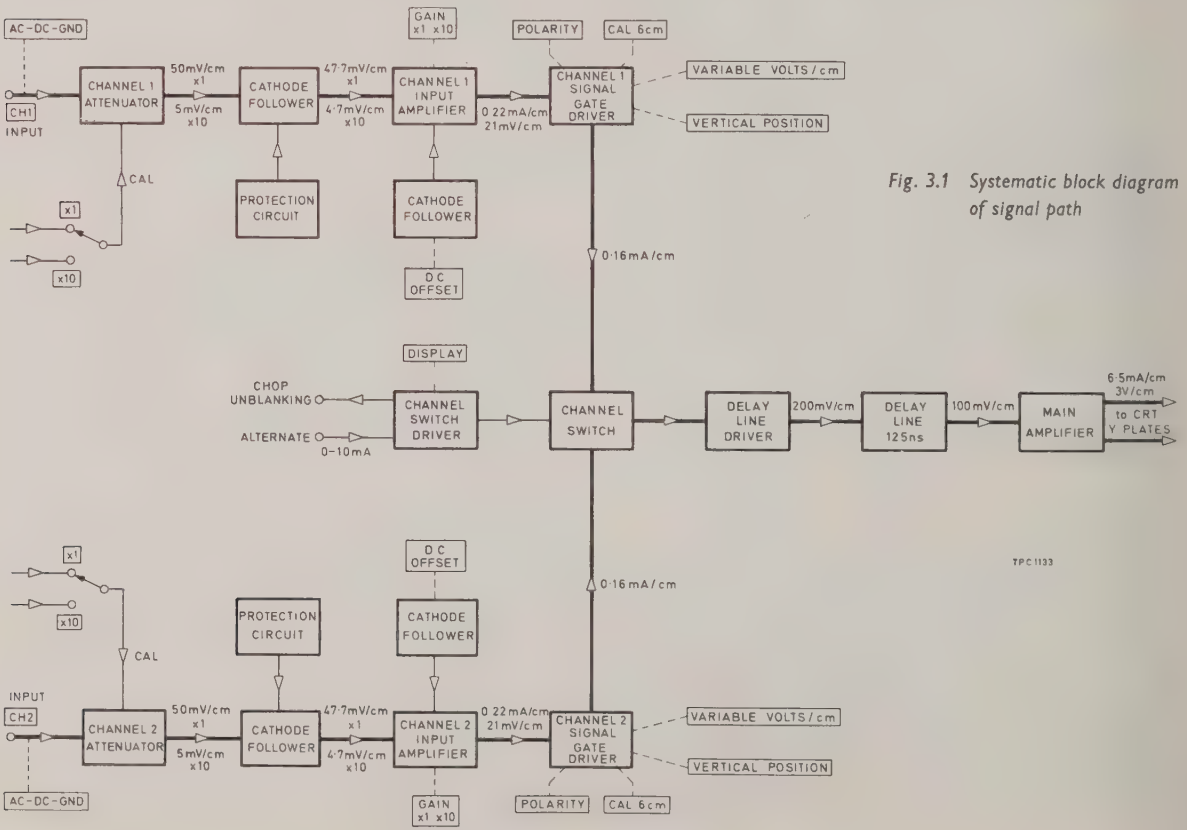


Fig. 3.1 Systematic block diagram of signal path

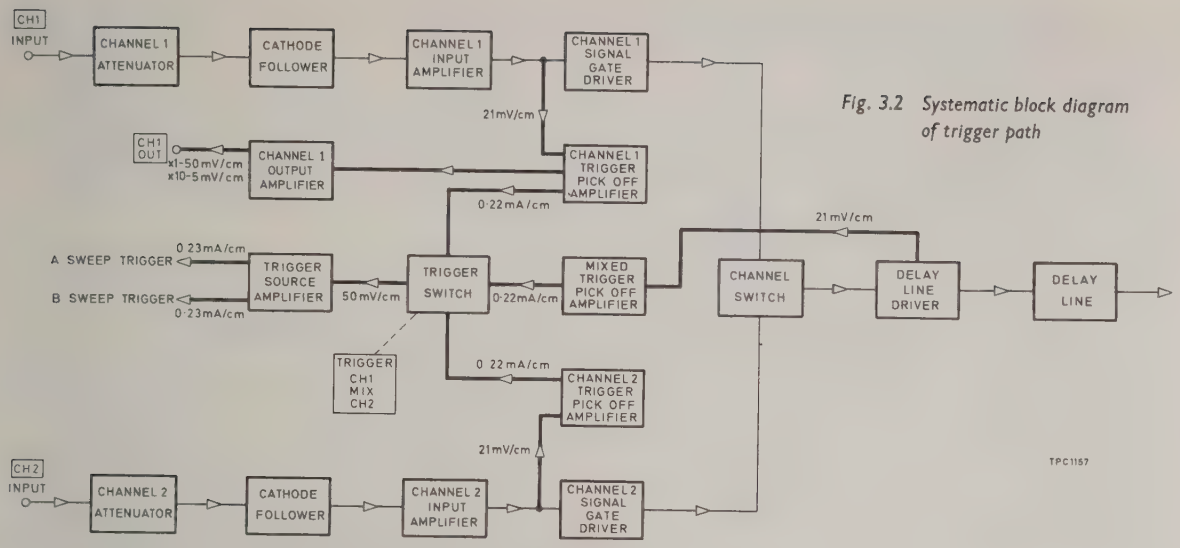


Fig. 3.2 Systematic block diagram of trigger path

The phase splitter supplies a balanced signal to a common base isolating stage either directly in the x1 GAIN position, or via a current amplifier having a gain of 10, in the x10 GAIN position. This amplifier is switched in or out of circuit by the use of diodes.

From the isolating stage, the signal passes to the signal gate driver which contains the POLARITY switch, VARIABLE VOLTS/CM and CAL 6 CM controls. The signal then passes to the channel switch which is a diode switch controlled by the channel switch driver.

From the channel switch the signal from either channel passes to the delay line driver. This drives a 130 ns delay line which feeds the signal to the main amplifier. The delay line allows observation of the leading edge when viewing fast pulses. The main amplifier amplifies the signal sufficiently to drive the vertical deflection plates of the c. r. t.

(ii) Trigger path

From each channel a signal is taken from the signal gate driver via the trigger pick-off amplifier and also from the delay line driver by the mixed trigger pick-off amplifier. These three signals, i. e. channel 1, channel 2 and mixed, are applied to a diode switch which is operated by the TRIGGER switch on the front panel. The output from the diode switch goes to the trigger source amplifier which provides a signal to both A and B sweep units simultaneously. From the channel 1 pick-off amplifier a signal is also taken to provide the channel 1 output circuit. The bandwidth switch is located in this circuit on the left-hand side of the dual trace unit.

(iii) Dual trace interconnection with main frame - see Fig. 3.3

The trace separation driver is fed from the A sweep unit and allows the trace separation

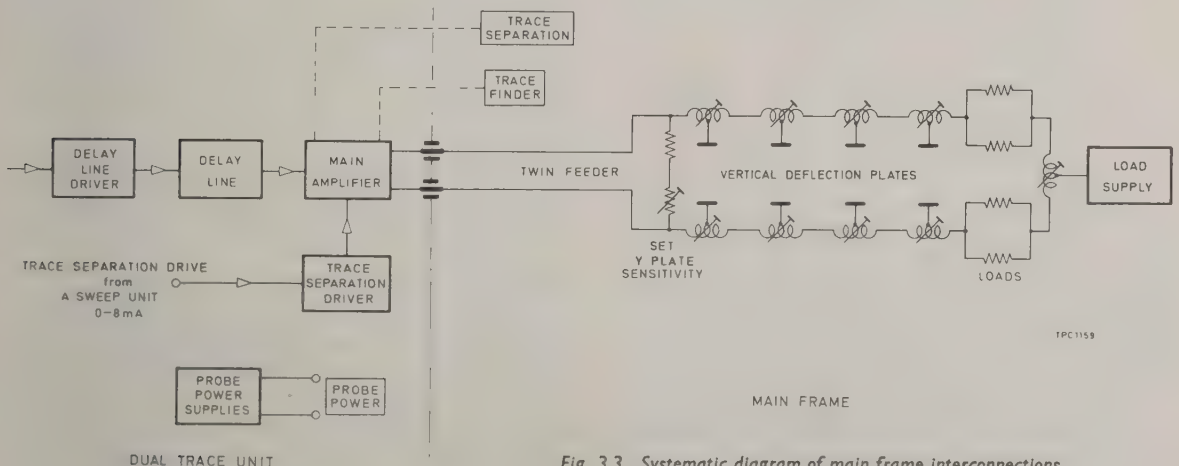


Fig. 3.3 Systematic diagram of main frame interconnections

control to displace the trace vertically during B sweep and not during A sweep, thereby providing separation in dual sweep modes.

Also on the main amplifier there is a connection for the TRACE FINDER. This limits the output of the amplifier to a signal within a 4 cm window on the screen. The main amplifier feeds the c.r.t. circuitry by means of a twin feeder line. Deflection of the trace in the c.r.t. is by four-section plates, connections being made to these plates by a series of inductors forming a transmission line. These inductors are adjustable, allowing the capacitance of the c.r.t. plates to be tuned into a resistive line with an impedance of about 560 Ω balanced. The use of distributed plates reduces the effect of transit time to negligible proportions therefore optimizing the frequency response of the c.r.t.

3.3 CIRCUIT ANALYSIS

The following description of circuits refers to channel 1 signal path only unless otherwise stated, since channel 2 is identical up to the delay line driver input.

Input attenuators (A21)

These are of twelve-position turret construction.

In the first position (0.05 V/cm) the input is connected to the cathode follower grid via the network shown below which gives zero attenuation, see Fig. 3.4.

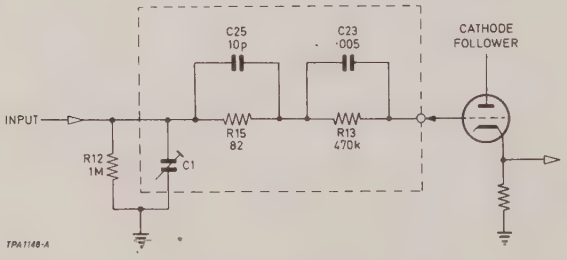


Fig. 3.4 Attenuator 0.05 V/cm position

The next ten positions (see Fig. 3.5) form the attenuator. This is a resistive L section divider having a constant input impedance of 1 MΩ. At high frequencies, compensation for the cathode follower input capacitance is provided by a π ladder of capacitors. As each range is selected, the shunt capacitance arm is replaced by the cathode follower input capacitance, also the appropriate trimmers for adjustment become accessible through holes in the turret housing.

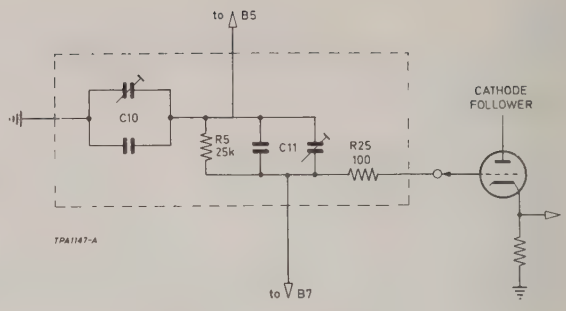


Fig. 3.5 Attenuator selection

On the first two positions (0.05 and 0.1 V/cm) C-R networks are added to provide compensation for fast pulse performance. On the last two positions (50 V and 100 V/cm) the series resistors which remove pulse disturbances are increased in value in order to minimize the effects of a high frequency resonance at the attenuator input. This reduces the bandwidth on these two positions to about 70 MHz.

Cathode followers (A22)

One of the two cathode followers, V2, supplies the signal from the attenuator to the phase splitter in the input amplifier, VT1a, and the other cathode follower, V1, supplies the d.c. offset voltage to the other side of the phase splitter, VT1b.

The twelfth position of the attenuator connects the cathode follower input to the internally generated 1 kHz calibrator square wave. The amplitude is 300 mV in the x1 GAIN position and 30 mV in the x10 GAIN position, providing a 6 cm calibration display.

The voltage at the grid of the signal cathode follower, V2, is nominally zero with no input. The anode voltage for both valves is derived from a low impedance supply to eliminate Miller effects. This voltage is set to obtain +1.5 V at the cathode of V2. The cathode of V1 is set to +1.5 V by adjustment of the preset offset control, RV1, on board A22 with the DC OFFSET control in its mid-position.

The use of two cathode followers improves warm up drift and reduces the effects of supply line disturbances.

Cathode follower protection circuit (A22)

To avoid damage to the signal cathode follower when an excessive overload is applied at the input, a protection circuit is provided. When a large negative voltage is applied to the input, the grid/cathode voltage is prevented from exceeding -80 V

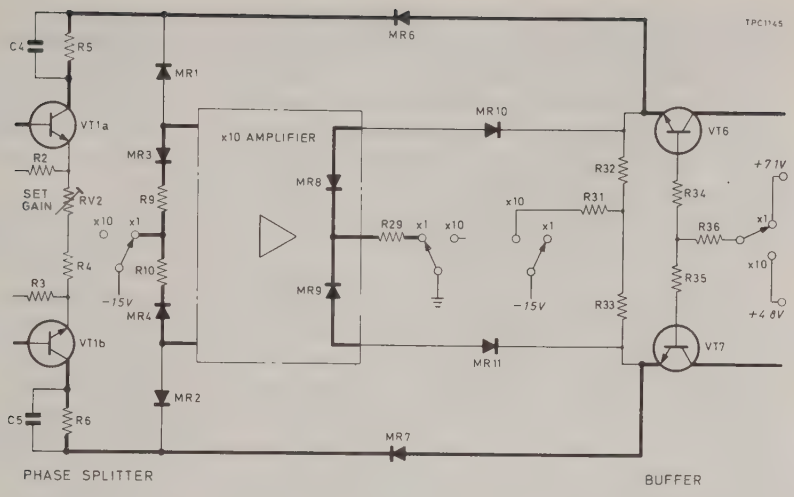


Fig. 3.6 Diagram indicating the signal path when the GAIN switch is in the x1 position

by a small neon across the grid and the cathode. The neon strikes at -80 V and sustains at -60 V. Diodes MR1 and MR2 prevent the cathodes from exceeding -0.7 V and thereby protect the phase splitter during overload and switch-on.

When a large positive voltage is applied at the input, a series diode, MR3, turns VT2 on. This reduces the base voltage of VT1, causing MR4 to turn off and the anode voltage of V2 to fall until the cathode current returns to near its normal value. The circuit thus maintains a constant cathode current when the grid voltage is increased. The power dissipation in the cathode follower, V2, is reduced.

Phase splitter (A23 channel 1; A24 channel 2)

This is a series feedback long-tailed pair stage having a voltage-to-current transfer characteristic. The phase splitting action is achieved by applying the unbalanced signal to one base, VT1a, and the fixed potential (d.c. offset via a cathode follower) to the other, VT1b. VT1a acts as a series negative feedback stage whilst VT1b acts as a common base stage providing the two antiphase collector currents.

The transfer conductance of the stage is preset by a potentiometer, RV2, between the emitters of VT1a and VT1b. The trimmer, C3, adjusts the fast rise time response; RV1 and C2 allow for matching a 10 ns time constant on both channels.

Resistors R5 and R6 and capacitors C4 and C5 minimize thermal effects by operating the stage at the point of maximum power.

x1/x10 gain switching (A23 and A24)

The gain switching is carried out by diodes which allow remote d.c. switching from the front panel. Figs. 3.6 and 3.7 show the diode circuitry.

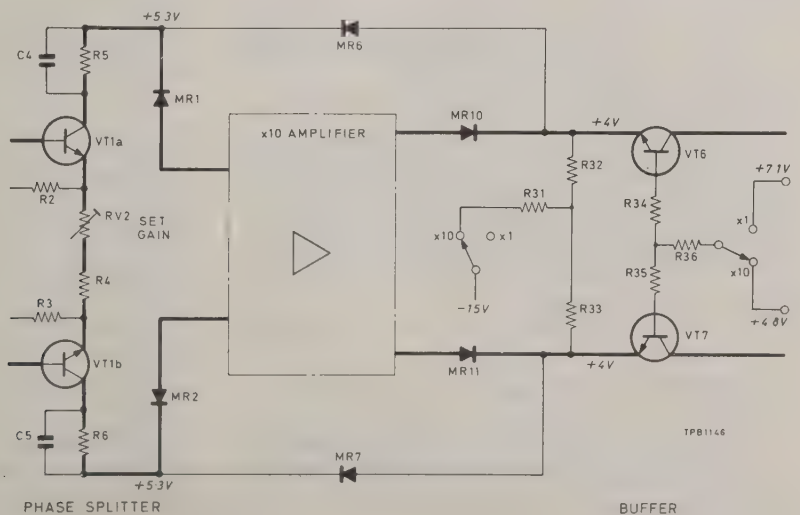


Fig. 3.7 Diagram indicating the signal path when the GAIN switch is in the x10 position

In the x1 GAIN position the input and the output of the x10 amplifier are both biased to disconnect the series diodes MR1, MR2, MR10 and MR11. The series diodes, MR6 and MR7, conduct and maintain a low impedance load for the phase splitter. The input of the x10 amplifier is biased off by diodes MR3 and MR4 to the -15 V line. The output is biased off by MR8 and MR9 to ground, via R29.

In the x10 GAIN position the input of the x10 amplifier is at the same potential as the output of the phase splitter, therefore the series diodes, MR1, MR2 and the output series diodes, MR10, MR11 conduct. The base voltage of the buffer, VT6 and VT7, is reduced and MR6 and MR7 are cut off. Since the direction of the current from the output is in opposition to that in the buffer stage, tail resistors R32 and R33 are required.

x10 amplifier (A23 and A24)

This amplifier is a current amplifier having a low input impedance and a high output impedance. The low input impedance is provided by the use of a shunt negative feedback stage. This also has a low output impedance suitable for driving the second stage, which is a series negative feedback stage, providing the required high output impedance. The x10 balance is provided by RV3. Diode MR5 prevents excessive excursion of VT2 base under overload conditions. The amplifier gain is adjusted by RV4 connected between the emitters of VT4 and VT5. C12 adjusts the fast rise time response and C15, RV5 provide a 10 ns compensation. Resistors R13, R14, R21 and R23 and capacitors C9, C10, C13 and C14 minimize thermal effects in the two stages.

Buffer stage (A23 and A24)

This is a common base stage providing good isolation in a current amplfier, having a low input impedance and high output impedance.

Resistors R34, R35 and R36 in the base circuit prevent any Colpitts oscillations in the stage. The variable resistor, RV6, in the emitter circuit is provided to set the common mode current on x10 to be equal to that on x1.

Signal gate driver (A25)

(i) POLARITY switching

Signal polarity is switched by means of a small slider switch, SG (A20) on channel 1 and SH (A20) on channel 2, connected between the buffer stage, after the x10 amplifier, and the signal gate driver. The cross coupling leads on the switch are connected at the centre point, equalizing the signal path length on both the NORMAL and INVERT positions, for optimum pulse performance.

(ii) VARIABLE VOLTS/CM and CAL 6 CM controls

These form a current shunt. Series resistors R73 and R74 form a collector load for the input amplifier buffer stage. The voltage produced across this load is used to supply the trigger pick-off amplifier. Shunting is provided across these resistors by the controls RV5 and RV6, (A20).

The CAL 6 CM control is removed from circuit by SJ (A20) when the VARIABLE VOLTS/CM control is not in the CAL position. This is to prevent amplifier limiting appearing on the screen under overload conditions.

The VARIABLE VOLTS/CM and the CAL 6 CM controls are connected to the input side of the POLARITY switch. This allows the inductance of the switch wiring to be included, giving improved pulse performance of the VARIABLE VOLTS/CM and the CAL 6 CM controls.

(iii) Common base stage

VT19 and VT20 provide isolation for driving the signal gate, and a low impedance for the variable gain network. Resistor R88 in the base lead prevents Colpitts oscillation.

Resistors R98 and R99 and capacitors C20 and C21 minimize thermal effects and limit the transistor power dissipation when the signal gate is closed.

Gain balance (A25)

With the polarity balance set, i.e. no trace movement when the POLARITY switch is operated, gain balance may be obtained by adjustment of RV4. This compensates for difference in the V_{be} voltages of VT19 and VT20 to give zero voltage across the gain control. The current balance from VT19 and VT20 is restored by the position balance control, RV6.

Position control (A25)

This consists of a variable balanced voltage, from a dual ganged potentiometer, feeding a variable balanced current change to the signal gate

(having low input impedance), via high value series resistors R116 and R117. This ensures that the loop impedance seen by the gate remains high enough to eliminate diode drift effects.

Signal gates (A25)

The operation of the diode gates is as shown in Fig. 3.8 the drive being applied to point A (channel 1). When the gate is open, the thermal drift in the series diodes has negligible effect since the loop impedance is high. When the gate is closed, the collector load impedance for the common base stages remains low, since diodes MR27 and MR28 are conducting. There is therefore only a very small signal voltage at the junction of the diodes. Since the series diodes are cut off, the breakthrough is minimized.

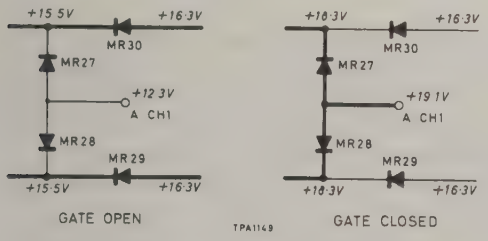


Fig. 3.8 Operation of the diode gates

Trigger pick-off amplifier (A25)

The separate channel trigger sources are derived from the voltage developed across the series resistors in the variable gain network. The actual point of pick-off is before the POLARITY switch. This allows the simple inversion of the picture displayed on the screen without affecting the triggering. Also, since the trigger is taken off after the x10 amplifier, the trigger sensitivity is constant on x1 and x10 GAIN positions. This also applies for the operation of the VARIABLE VOLTS/CM and the CAL 6 CM controls. The trigger sensitivity referred to is in terms of screen deflection required for triggering.

The trigger pick-off amplifier is a cascade amplifier having a high input impedance for minimum effect on signal path and a high output impedance for driving the trigger selection gates.

On the channel 1 side there is an intermediate pick-off after the series negative feedback stage, producing a voltage for the channel 1 output facility. This voltage is bandwidth limited by capacitors C13 and C14 across series resistors R57 and R58. This reduces the Miller effect at high frequencies in the series feedback stage. The bandwidth, however, to the trigger gate is not affected. The series feedback resistor, R52, and resistors R57 and R58, are of close tolerance to maintain a control of the gain from the pick-off point to the channel 1 output, for setting channel 1 gain by use of channel 1 output. The common base stage, completing the cascode amplifier, provides the required low input impedance for elimination of Miller effect and has a high output impedance for driving the trigger gates and isolating them from the series feedback stage. The base voltages in the channel 1 common base stage are strapped to the +15 V line via Zener diode MR14. This improves the supply line ripple rejection at the channel 1 output.

On the channel 2 side, resistors R59 and R60 are used between the series feedback and common base stages to reduce the possibility of oscillation. The mixed trigger pick-off amplifier comprises a series negative feedback stage only, since the take-off point is the output of the delay line driver. To reduce both signal level and d.c. level to that of the separate channel points, a potential divider, R105, R106, R107 and R108, is used.

All three sources of trigger signals incorporates a balance control. These controls, RV2, RV3 and RV8, should each be set, with balanced amplifier conditions, for a balance at the output of the trigger source amplifier with the A and B sweep units removed from the oscilloscope.

Trigger selection gates (A25)

These gates are identical in operation to the signal gates except that the current flow is in the opposite direction and they are operated by the TRIGGER switch on the front panel. When a gate is conducting, the trigger signal is developed across R75, R76 at a voltage sensitivity of 50 mV/cm.

Trigger source amplifier (A25)

This is a series negative feedback stage which converts the 50 mV/cm, developed across R75 and R76, into a current that drives the A and B sweep units at a sensitivity of about 0.23 mA/cm each. The capacitor, C17, across the emitter circuit provides a lift in gain at high frequencies in order to maintain h.f. trigger performances.

Channel 1 output stage (A25)

The voltage across R57 and R58 drives the series negative feedback stage, VT11 and VT12. Resistors R53 and R37 are of close tolerance to give good gain stability, assuming a nominal setting of the balance control, RV1. Transistor

dissipation is limited by R42 and R43 whilst R38 provides a convenient point for connection of the bandwidth limiting capacitor, C9, (connection to earth will produce pulse ripples). Compensation of frequency response in the wide band position is obtained by R-C networks between the emitters.

Diode MR12 protects the output stage should an external voltage be applied to the CH1 OUTput socket. (In the event of a serious overload only the emitter follower should be damaged.) The series diode, MR13, compensates for thermal drift in V_{be} in the emitter follower output stage VT8. The 50 Ω output impedance is obtained with R33 which, when added to the nominal emitter follower output impedance of about 3 Ω, gives 50 Ω. Capacitor C16 removes unblanking ripple from the channel 1 output signal when the dual trace unit is used in the cascaded mode.

Delay line driver stage (A25)

The delay line driver is a shunt negative feedback stage giving a low input impedance for efficient operation of the signal gates and a mismatch with the signal gate driver for good h.f. performance. The low output impedance is required to ensure a well defined sending end termination for the delay line using resistors R121 and R122.

Resistors R118 and R119 and capacitors C24 and C25 in the collector circuit minimize thermal effects. The emitter connection of VT27 and VT28 is taken to the +6.3 V line via R120 to minimize the common mode input impedance. Diodes MR35 and MR36 prevent excessive excursion of the base voltages under overload conditions.

Delay line (A25)

This is helically wound cable of a bifilar construction giving a line of good pulse performance, an impedance of about 160 Ω balanced and a delay of about 130 ns at 19 ns/ft. The cable is screened to minimize pre-shoot. Resistors R123 and RV9 allow adjustment of the terminating impedance for matching the line.

Main amplifier (A26)

(i) 1st stage

This is series negative feedback stage driven from the low impedance of the delay line. The gain is fixed by the emitter resistor, R5. Across

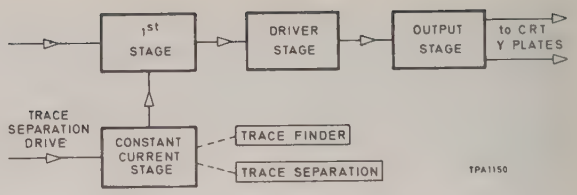


Fig. 3.9 Systematic block diagram of the main amplifier

R5 there is a C-R network, RV2 and C3, for compensation of delay line losses; C1, C2 and RV1 ensure a fast pulse response and C6, C23, R12, R13 and R38 compensate for residual thermal effects. The C-R network in each collector lead minimizes thermal effects and the stopper resistors, R3 and R4, in each base lead prevent spurious oscillation.

(ii) Constant current stage

In the emitter circuit of the first stage is the constant current stage allowing an injection of trace separation current without affecting the performance of the main amplifier signal path. Resistors R9 and R10 prevent oscillation of VT3 and VT4 together with R11 in the common base lead. The trace separation signal is injected as a current at the low impedance point in the emitters of VT3 and VT4 via resistors R14 and R17 from the dual gang potentiometer A0 RV5 (TRACE SEPARATION). When A sweep is running, the separation is cut off by the diode bridge MR1-4. On B sweep the bridge opens, allowing separation. RV3 provides a means of balancing the main amplifier.

The constant current stage also limits the amount of signal fed to the c.r.t. plates when the TRACE FINDER button is pressed. The current in VT1, VT2, VT3 and VT4 is limited to about 2 mA in each transistor by R20 in the VT3 and VT4 emitter circuit giving a maximum deflection of ±2 cm.

A change in d.c. conditions is prevented by R21 which restores the collector supply voltage in the first stage and avoids trace de-focusing.

(iii) Driver stage

This is a series negative feedback stage driving the output stage. The gain is kept low in order to minimize Miller effects and maintain good h.f. performance. The main amplifier gain is set by RV4 between the emitters of VT5 and VT6. C8 is set for fast pulse performance and compensates for the capacitive loading in the output stage.

Output stage (A26)

This uses a cascode stage giving a high input impedance with minimum Miller effects and a high output impedance.

The first stage, with series negative feedback, provides the high input impedance and requires the highest frequency transistors. Thermal effects, which are most pronounced in this stage, are minimized by resistors R36 and R37, which operate the stage about the point of maximum power. This minimizes the transistor power change with signal. Zener diodes MR5 and MR6 prevent saturation of VT7 and VT8 under overload conditions. Capacitors C16 and C17 remove Miller effects at high frequencies. C13 adjusts for fast pulse performance and RV5 and C15 provide a 1 μs compensation for residual thermal effects.

The second stage, formed by common base transistors VT1 and VT2 (A20), feeds the c.r.t. plate delay line in TF 2210 via a twin feeder from the dual trace plug-in unit. The ferrite beads, X8 and X9, and resistor R43 prevent Colpitts oscillation of the stage.

Supply line filters

Capacitors C7, C10, C11, C12, C14, C18 and C19 and ferrite beads X1 - X7 form filters for rejection of unwanted signals from the power supply lines.

Channel switch driver (A25)

This is a bistable circuit, VT5 and VT7, which is switched for five different modes as follows:

(i) Alternate: In this mode it is essential that a fixed relationship between the channels and sweeps is maintained when working in dual trace and dual sweep modes. To obtain this, direct coupling is used for vertical alternate switching.

The bistable circuit around VT5 and VT7 becomes a Schmitt trigger. The drive from the sweep unit is transmitted via a 50 Ω cable to the terminating network, R3 and VT1. The current is converted into the required voltage swing at the collector of VT1, driving the base of VT5, whilst the base of VT7 is connected to the low impedance of MR1, via R32. The emitters are strapped together by diodes MR6 and MR10. Diode MR2 prevents a large excursion in VT5 base voltage which would produce large changes in VT5 collector current and possibly transistor saturation. The collector circuit is clamped by diodes MR4, MR5, MR8 and MR9. This prevents large excursions of signal gate drive voltage and saturation of VT5 and VT7.

(ii) Channel 1: In this, and remaining modes, the alternate drive is disconnected from the base of VT5. The emitter clamping diodes MR6 and MR10 are allowed to float. Transistor VT5 is switched on by R13 whilst VT7 remains switched off.

(iii) Add: In this mode both signal gates must be open. This is achieved by switching off VT5 and VT7 and removing the +45 V collector load supply. This supply is then utilized to provide the extra current to the delay line driver bases via R110 and R111, to restore d.c. conditions when both signal gates are open.

(iv) Channel 2: This mode is identical to channel 1 except, of course, that VT7 is switched on and VT5 switched off, via R31.

(v) Chop: In this mode VT5 and VT7 form an emitter coupled free running bistable using C5 and emitter resistors R16 and R27.

With the double cross coupling from collector to base, R17, R12, R20 and R30, the current through the common emitter supply peaks at each transition. This pulse is used, via transformer T1, to switch VT3 which provides the blanking pulse to the unblanking amplifier. Capacitors C4 and C7 ensure that the circuit starts oscillating at the required 1 MHz. The blanking pulse from VT3 is a defined current through T24 which drives the unblanking amplifier input (-0.7 V, 50 Ω impedance). The blanking pulse shape is optimized by C3. R10 minimizes the voltage swing on the transformer windings. Resistors R28 and R29 and capacitor C8 minimize disturbances caused by transistor switching, particularly on chop mode.

Trace separation drive (A25)

The diode bridge, MR1 - MR4, in the constant current stage of the main amplifier is driven from the long-tailed pair circuit of VT2 and VT4. This is operated by the separation signal from the A sweep unit via VT6 and a 50 Ω coaxial line terminated by R6. MR11 limits the current in VT4.

Chapter 4

Maintenance

4.1 INTRODUCTION

This chapter contains information for keeping the equipment in good working order and for checking its overall performance.

Before attempting any maintenance on the oscilloscope you are advised to read the preceding technical description chapter.

CAUTION

This instrument uses semiconductor devices which, although having inherent long term reliability and mechanical ruggedness, are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers or accidentally applied short circuits. Even the leakage current from an unearthed soldering iron could cause trouble. Before shorting or breaking any circuit, refer to the circuit diagrams to establish the effect on bias arrangements of the transistor.

4.2 SCREW FASTENERS

Screw threads used on this instrument are of the following sizes: 4 BA, 6 BA, 8 BA.

Cruiciform headed screws are of the Pozidriv pattern; to avoid damaging them a Pozidriv screwdriver should be used.

4.3 LOCATION OF SUB-ASSEMBLIES

Figs. 4.1 and 4.2 show the location of the printed boards. Sect. 4.4 details the removal of boards for access.

4.4 ACCESS TO SUB-ASSEMBLIES

(1) Delay line

Unscrew the four 6 BA Pozidriv screws holding the delay line to the outer rails of the chassis. (These screws also hold the cableform along each rail.) In board A25, there are five holes through which flying lead connectors pass to the pins on the delay line. Remove these push-on connectors and extract the flying leads through the holes. Lift out the delay line. The underside of board A25, and the previously concealed part of board A26, are now accessible. The two cable forms, mentioned above, are also free to move as required.

(2) Probe power supply board (A27)

Access to the underside of board A27 may be obtained by removing the four 6 BA screws holding the board to the bracket. The board may then be lifted out, hinging on its connecting cableform.

(3) Channel 1 and channel 2 input amplifier, boards A23 and A24 (the following description applies to both boards).

Remove the push-on flying lead connectors, from board A25, on pins 13, 16 and 17.

Remove the push-on flying lead connectors, from the cathode follower circuitry on pins 14 and 15.

Unscrew the outer two 6 BA Pozidriv screws and manœuvre the board out of the chassis leaving it still connected by the cable form at the rear of the board.

By removing boards A23 and A24, improved access to the cathode follower assembly is provided.

(4) Input cathode follower, board A22

Access to most of the underside of this board may be obtained by removing the flat earthing strips which earth the attenuator turret housing to the chassis. Further access may be obtained by removing the screening plate immediately behind the front panel.

Then by removing the pillars on the board, to which the screening plate was attached, and the two 6 BA screws, the board may be pulled out a short distance on its connecting wires.

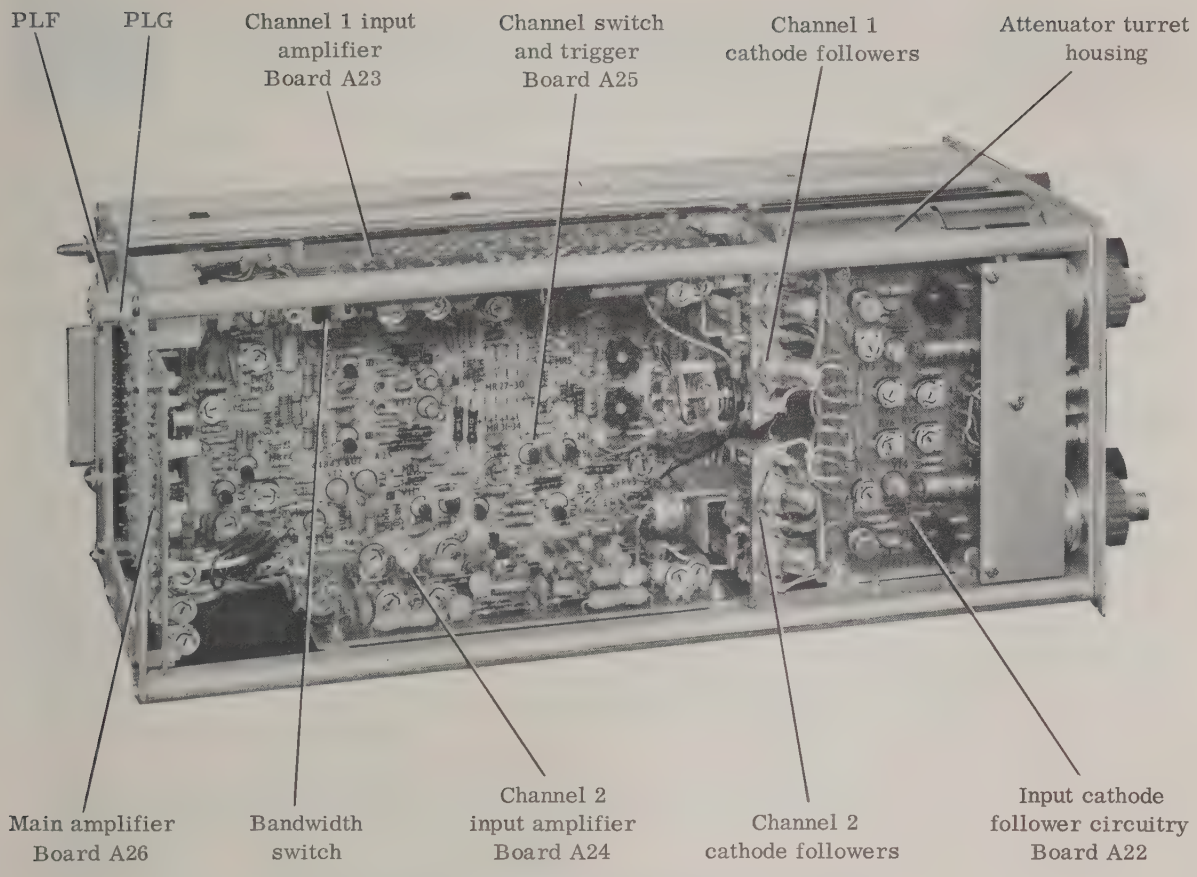


Fig. 4.1 Left side of unit

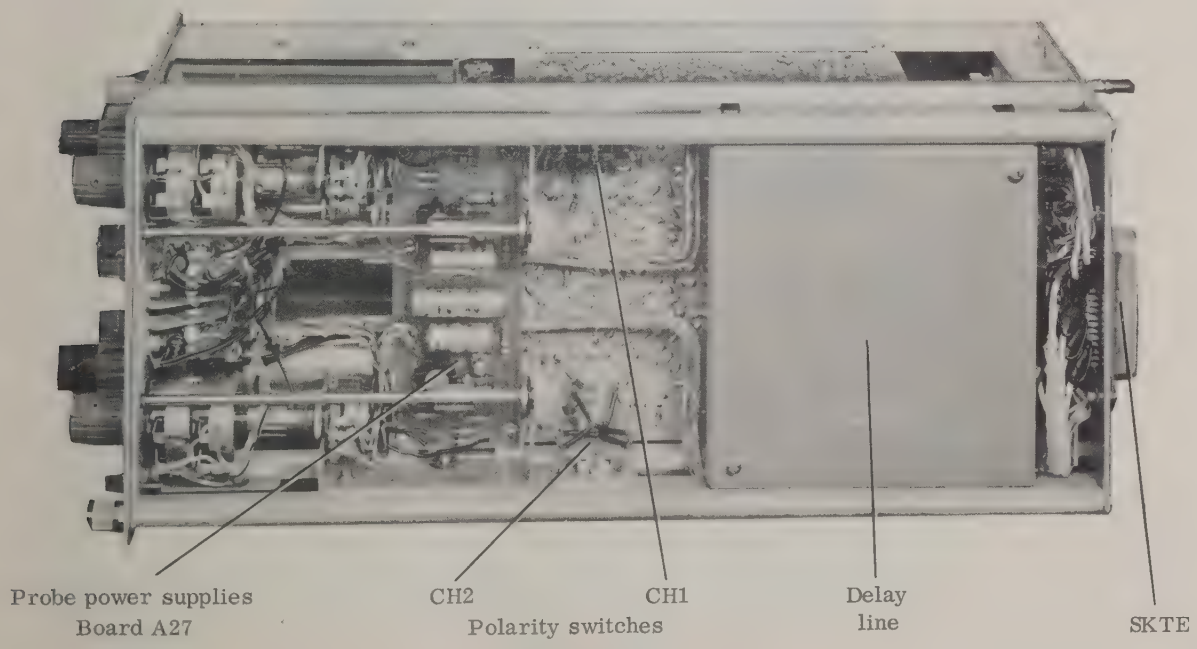


Fig. 4.2 Right side of unit

(5) Input attenuators
(The following description applies to both attenuators.)

By removal of the 4 x 6 BA screws on the top of the turret housing, the cover may be lifted off and access gained to the individual attenuator segments. All grey coloured segments may be extracted by lifting them out at the front end. The two red segments can be removed by the same method but a wire must first be unsoldered from the front end of the segments.

CAUTION

Extreme care must be taken when removing the attenuator section since the critical alignment may be affected.

4.5 TEST POINTS

Test points are provided on the printed boards for making measurements of waveforms or static voltages. The board legends in Sect. 5.2 show clearly where the test points are located and the circuit diagrams indicate typical readings found on each test point. The readings shown were taken with the front panel controls set as described in the TF 2210 manual in Sect. 4.5.

Note: Any variation of these control positions for certain measurements is indicated on the circuit diagram.

Chapter 5

Repair

5.1 INTRODUCTION

This chapter is intended to help you quickly trace any component on the printed circuit boards.

CAUTION

See Sect. 4.1 for precautions in handling semiconductor devices.

In case of any difficulty, please write to or phone the Marconi Instruments Service Division (see address on back cover) or nearest representative, quoting the type and serial number on the data plate of the instrument. If the oscilloscope is being returned for repair, please indicate clearly the nature of the fault or the work you require to be done.

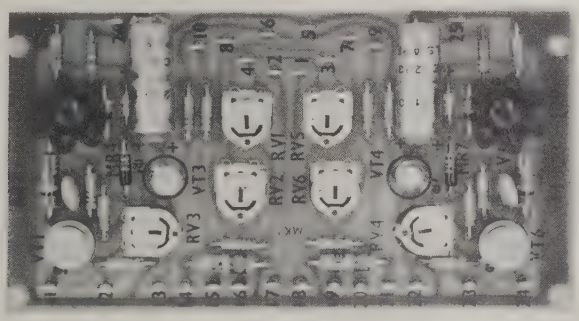
5.2 COMPONENT LOCATION

There follows a photograph and a legend diagram for each printed board in the unit, Fig. 4.1 and Fig. 4.2 illustrate the location of the boards in the instrument.

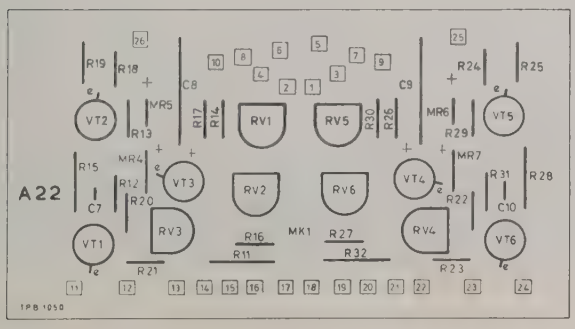
5.3 REPLACEMENT OF COMPONENTS

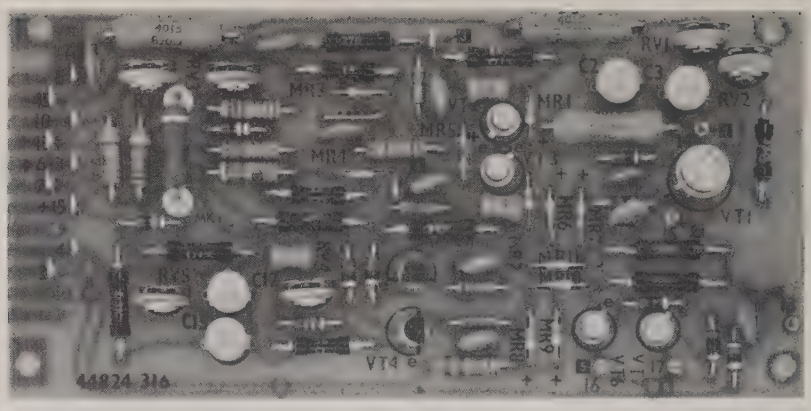
Nuvistors or transistors should not be replaced unless they are actually defective. If these components are removed from any printed board and found to be acceptable, they should be returned to their original socket. It is advisable not to use test equipment for checking transistors or nuvistors because the tester may fail to indicate a defect which will affect the performance of the circuit. It is therefore recommended that transistors or nuvistors are checked by a method of substitution. Unnecessary replacement of these components is expensive and may also result in needless recalibration of circuits.

For precautions whilst replacing semiconductor devices see Sect. 4.1.



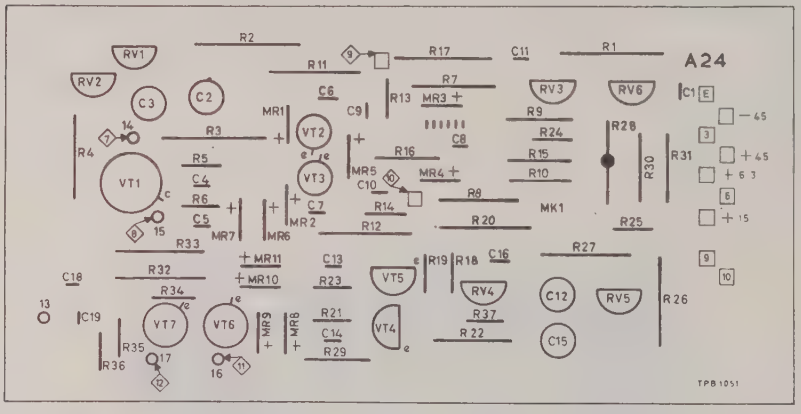
A22 Input cathode follower (Fig. 7.1)



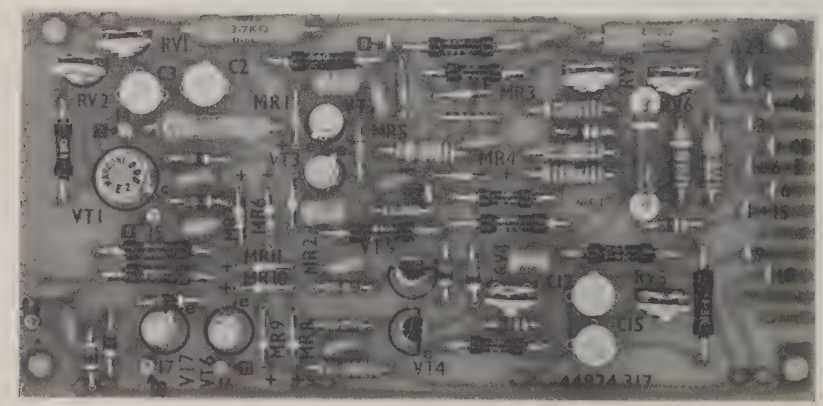


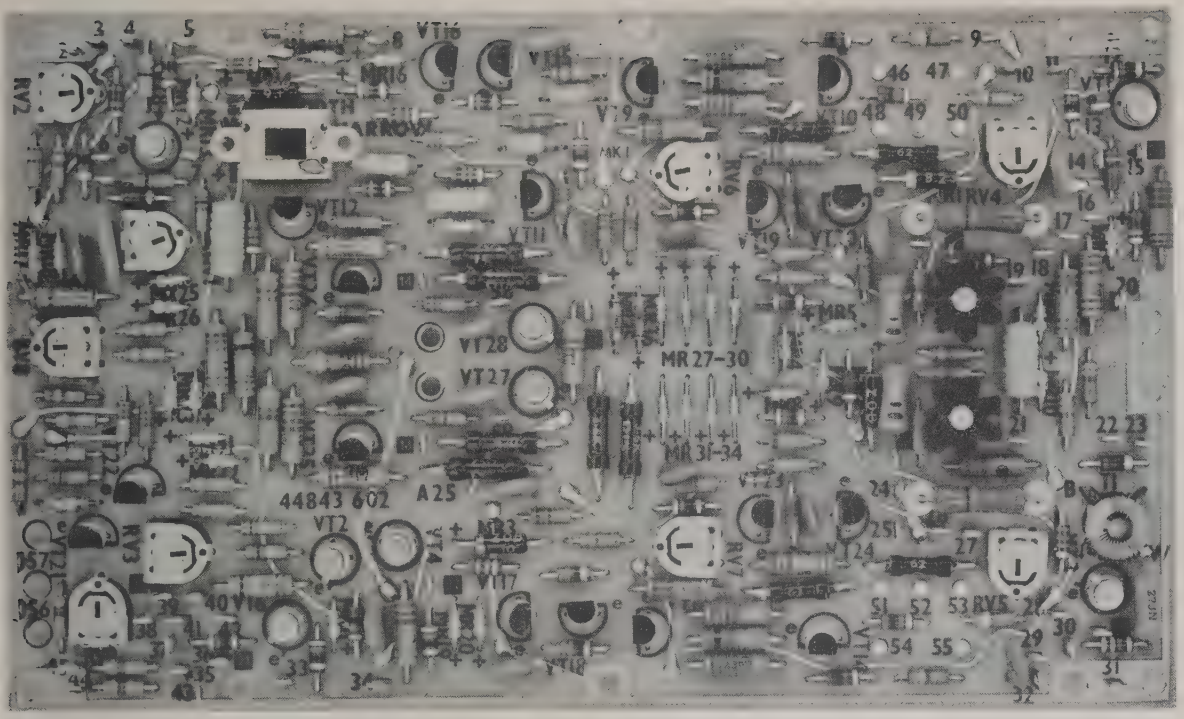
A23 Channel 1 input amplifier (Fig. 7.2)

NOTE: The component layout on A23 is the mirror image of that on A24; therefore use the legend diagram for A24 for locating components.

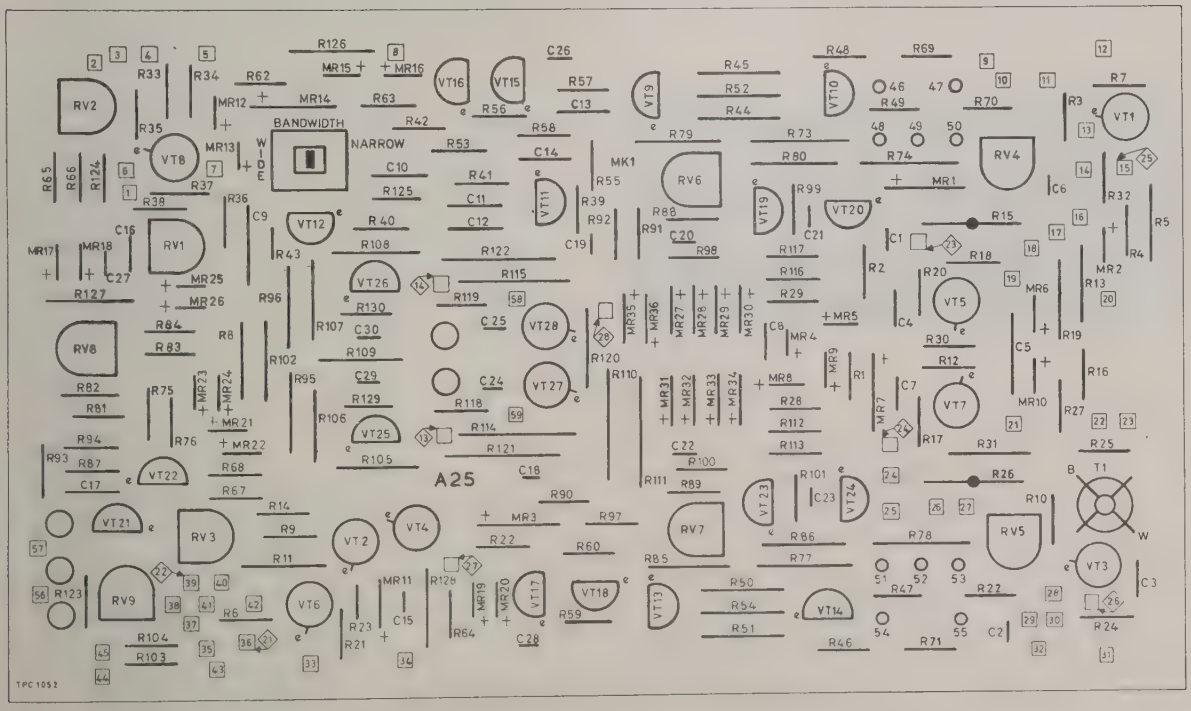


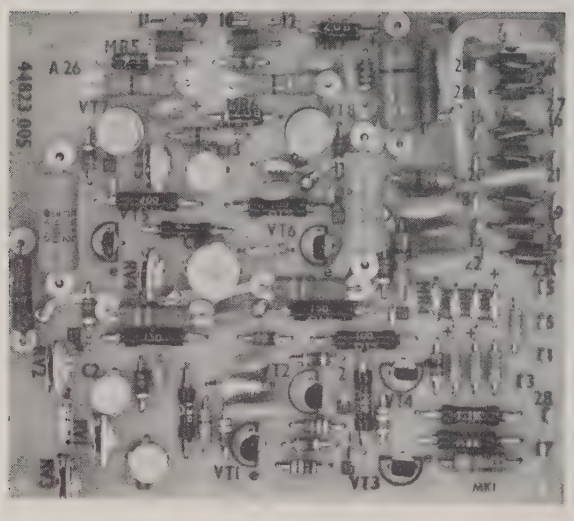
A24 Channel 2 input amplifier (Fig. 7.2)

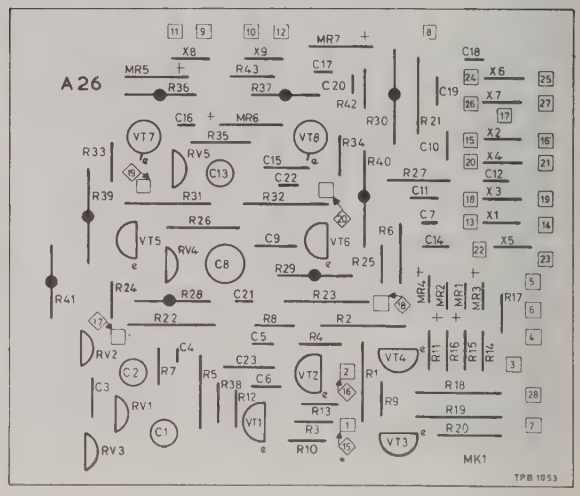




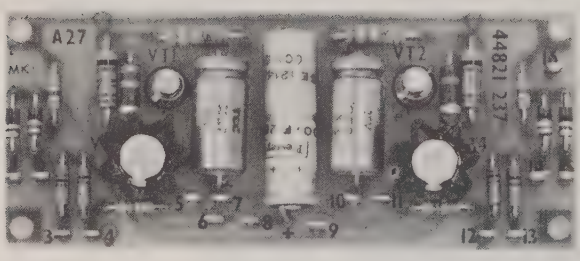
A25 Beam switching and trigger (Fig. 7.3)

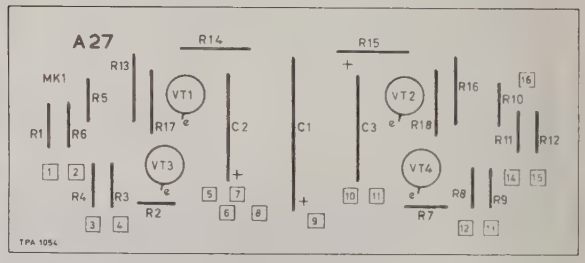






A26 Main amplifier (Fig. 7.4)





A27 Probe power supply

Index to Units

Unit number	Description	Parts list page	Circuit diagram Fig.
A0 to A19 inclusive, see manual EB 2210			
A20	Vertical plug-in interconnection	26	7.5
A21	Attenuator	27	7.1
A22	Input cathode follower	27	7.1
A23	Channel 1 input amplifier	28	7.2
A24	Channel 2 input amplifier	29	7.2
A25	Beam switching and trigger	31	7.3
A26	Main amplifier	34	7.4
A27	Probe power supply	35	7.5

Chapter 6

Replaceable parts

Introduction

Each of the printed boards and other sub-assemblies in this plug-in has been allocated a unit identification number in the sequence A20 to A27. The replaceable parts are listed in alpha-numerical order under a main heading of the unit number, unit description and the associated circuit diagram number.

For convenience in the text and on the circuit diagrams, the unit identification is is only used with components when there is a risk of ambiguity.

In the replaceable parts list the following abbreviations are used:-

C : capacitor
B : attenuator segment
Carb : carbon
Cer : ceramic
Elec : electrolytic
ILP : indicator light
L : inductor
Met : metal
MR : semiconductor diode
Ox : oxide
PL : plug
Plas : plastic
R : resistor
RV : variable resistor
S : switch
SK : socket
T : transformer
V : valve
Var : variable
Vm : volts maintained
Vs : striking volts
VT : transistor
WW : wire wound
X : ferrite bead
W : watts at 70 °C
W* : watts at 55 °C
W*** : watts at 20 °C

Ordering

When ordering replacement parts, address the order to our Service Division (for address see rear cover) or nearest Agent. Specify the following information for each part required:

(1) Type and serial number of instrument.
(2) Complete circuit reference and unit number.
(3) Description.
(4) M.I. code number.

If a part is not listed, state its function, location and description when ordering.

A20 Vertical plug-in interconnection (Fig. 7.5)

Circuit reference	*Description*	*M.I. code*
C1	Plas 0.047μF 20% 630V	26511-186
C2	Plas 0.047μF 20% 630V	26511-186
ILP1	500μA Vs80 Vm60	44731-402
ILP2	500μA Vs80 Vm60	44731-402
ILP3	500μA Vs80 Vm60	44731-402
ILP4	500μA Vs80 Vm60	44731-402
PLF	50Ω Coaxial	23445-145
PLG	50Ω Coaxial	23445-145
R1	Met ox 27Ω 5% ¼W	24581-205
R2	Met ox 27Ω 5% ¼W	24581-205
R3	Met ox 27Ω 5% ¼W	24581-205
R4	Met ox 27Ω 5% ¼W	24581-205
R5	Met ox 110Ω 5% ¼W	24581-217
R6	Met ox 110Ω 5% ¼W	24581-217
R7	Met ox 110Ω 5% ¼W	24581-217
R8	Met ox 110Ω 5% ¼W	24581-217
RV1	Carb 10kΩ 20% ½W Lin.	44371-236
RV2	Carb 10kΩ 20% ½W Lin.	44371-236
RV3	Carb 25kΩ +25kΩ 20% ½W Lin.	44371-238
RV4	Carb 25kΩ +25kΩ 20% ½W Lin.	44371-238
RV5	Carb 2kΩ 20% 1/10W Log.	44371-235
RV6	Carb 2.2kΩ 20% ¼W Log.	44371-230
RV7	Carb 2kΩ 20% 1/10W Log.	44371-235
RV8	Carb 2.2kΩ 20% ¼W Log.	44371-230

Circuit reference	Description	M.I. code
SA	Input switch CH1	44331-307
SB	Input switch CH2	44331-307
SC	GAIN channel 1	44321-138
SD	GAIN channel 2	44321-138
SE	TRIGGER switch	44322-138
SF	DISPLAY switch	44324-220
SG	POLARITY channel 1	23467-119
SH	POLARITY channel 2	23467-119
SJ	Part of RV5	
SK	Part of RV7	
SKA	Part of SA	
SKB	Part of SB	
SKC	50Ω coaxial	23443-443
SKD	3 pin	23427-121
SKE	36 way	23435-452
SKDA	3 pin	23427-121
VT1	Motorola 2N3866	28453-866
VT2	Motorola 2N3866	28453-866

A21 Attenuator (Fig. 7.1)

B1	Attenuator segment (red)	37575-417
B2	Attenuator segment (red)	37575-429
B3	Attenuator segment (grey)	37575-430
B4	Attenuator segment (grey)	37575-431
B5	Attenuator segment (grey)	37575-432
B6	Attenuator segment (grey)	37575-433
B7	Attenuator segment (grey)	37575-434
B8	Attenuator segment (grey)	37575-435
B9	Attenuator segment (grey)	37575-436
B10	Attenuator segment (grey)	37575-437
B11	Attenuator segment (grey)	37575-438
B12	Attenuator segment (grey)	37575-439

A22 Input cathode follower (Fig. 7.1)

C1	Plas 10pF ±1pF 125V	26516-009
C2	Cer 0.01μF +80-20% 100V	26383-055
C3	Cer 0.1μF +50-25% 30V	26383-031
C4	Plas 0.047μF 10% 250V	26582-206
C5	Cer 0.01μF +80-20% 100V	26383-055
C6	Cer 0.01μF +80-20% 100V	26383-055
C7	Cer 0.001μF +80-20% 500V	26383-242
C8	Elec 2μF +50-20% 150V	26417-107
C9	Elec 2μF +50-20% 150V	26417-107
C10	Cer 0.001μF +80-20% 500V	26383-242
C11	Cer 0.01μF +80-20% 100V	26383-055
C12	Cer 0.01μF +80-20% 100V	26383-055
C13	Cer 0.1μF +50-25% 30V	26383-031
C14	Plas 0.047μF 10% 250V	26582-206
C15	Cer 0.01μF +80-20% 100V	26383-055
C16	Plas 10pF ±1pF 125V	26516-009
L1	Inductor	44221-808
L2	Inductor	44221-808
MR1	Texas Inst. 1N916	28336-466
MR2	Fairchild BAY82	28335-186
MR3	Fairchild BAY82	28335-186
MR4	Silicon p-n-p	28336-676
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357-548
MR7	Silicon p-n-p	28336-676
MR8	Fairchild BAY82	28335-186
MR9	Silicon p-n-p	28336-676
MR10	Fairchild BAY82	28335-186
R1	Carb 1kΩ 10% ¼W	24341-280
R2	Carb 100Ω 10% ¼W	24341-250
R3	Met ox 5.6kΩ 10% ½W*	24552-103
R4	Carb 22Ω 10% ¼W	24341-228
R5	Carb 22Ω 10% ¼W	24341-228
R6	Met ox 5.6kΩ 5% ½W*	24552-103
R7	Carb 150Ω 10% ¼W	24341-254
R8	Carb 100Ω 10% ¼W	24341-250
R9	Carb 1000MΩ 20% W***	24288-490
R10	Carb 100kΩ 10% ¼W	24341-335
R11	Met ox 160Ω 5% ½W*	24552-055

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R12	Met ox 1.5kΩ 5% ¼W	24581-244
R13	Carb 10kΩ 10% ¼W	24341-310
R14	Met ox 12kΩ 5% ¼W	24581-266
R15	Met ox 20kΩ 5% ½W*	24552-117
R16	Met ox 5.6kΩ 5% ¼W	24581-258
R17	Met ox 1.5kΩ 5% ¼W	24581-244
R18	Met ox 330Ω 5% ¼W	24581-228
R19	Met ox 150Ω 5% ¼W	24581-220
R20	Met ox 7.5kΩ 5% ¼W	24581-261
R21	Met ox 36kΩ 5% ¼W	24581-277
R22	Met ox 7.5kΩ 5% ¼W	24581-261
R23	Met ox 36kΩ 5% ¼W	24581-277
R24	Met ox 330Ω 5% ¼W	24581-228
R25	Met ox 150Ω 5% ¼W	24581-220
R26	Met ox 1.5kΩ 5% ¼W	24581-244
R27	Met ox 5.6kΩ 5% ¼W	24581-258
R28	Met ox 20kΩ 5% ½W*	24552-117
R29	Carb 10kΩ 10% ¼W	24341-310
R30	Met ox 12kΩ 5% ¼W	24581-266
R31	Met ox 1.5kΩ 5% ¼W	24581-244
R32	Met ox 160Ω 5% ½W*	24552-055
R33	Carb 100kΩ 10% ¼W	24341-335
R34	Carb 1000MΩ 20% W***	24288-490
R35	Carb 100Ω 10% ¼W	24341-250
R36	Carb 150Ω 10% ¼W	24341-254
R37	Met ox 5.6kΩ 5% ½W*	24552-103
R38	Carb 22Ω 10% ¼W	24341-228
R39	Carb 22Ω 10% ¼W	24341-228
R40	Met ox 5.6kΩ 5% ½W*	24552-103
R41	Carb 100Ω 10% ¼W	24341-250
R42	Carb 1kΩ 10% ¼W	24341-280
R43	Carb 22Ω 10% ¼W	24341-228
R44	Carb 22Ω 10% ¼W	24341-228
R45	Carb 22Ω 10% ¼W	24341-228
R46	Carb 22Ω 10% ¼W	24341-228
RV1	Carb 10kΩ 10%	25541-377
RV2	Carb 10kΩ 10%	25541-377
RV3	Carb 10kΩ 10%	25541-377
RV4	Carb 10kΩ 10%	25541-377
RV5	Carb 10kΩ 10%	25541-377
RV6	Carb 10kΩ 10%	25541-377
V1	Nuvistor R.C.A. 7586	28127-488
V2	Nuvistor R.C.A. 7586	28127-488
V3	Nuvistor R.C.A. 7586	28127-488
V4	Nuvistor R.C.A. 7586	28127-488
V5	Neon lamp	23733-103
V6	Neon lamp	23733-103
VT1	High voltage n-p-n	44522-018
VT2	Fairchild C407	28458-266
VT3	Mullard BC107	28455-437
VT4	Mullard BC107	28455-437
VT5	Fairchild C407	28458-266
VT6	High voltage n-p-n	44522-018

A23 Channel 1 input amplifier (Fig. 7.2)

C1	Cer 0.01μF +80-20% 100V	26383-055
C2	Cer 2.5-6pF +50-10% 160V	26847-108
C3	Cer 2.5-6pF +50-10% 160V	26847-108
C4	Cer 0.001μF +80-20% 500V	26383-242
C5	Cer 0.001μF +80-20% 500V	26383-242
C6	Cer 1.5pF ±0.25pF 750V	26324-008
C7	Cer 1.5pF ±0.25pF 750V	26324-008
C8	Cer 0.01μF +80-20% 100V	26383-055
C9	Cer 0.001μF +80-20% 500V	26383-242
C10	Cer 0.001μF +80-20% 500V	26383-242
C11	Cer 0.01μF +80-20% 100V	26383-055
C12	Cer 2.5-6pF +50-10% 160V	26847-108
C13	Cer 0.001μF +80-20% 500V	26383-242
C14	Cer 0.001μF +80-20% 500V	26383-242
C15	Cer 4.5-20pF +70-10% 160V	26847-114
C16	Cer 6.8pF ±2.5pF 750V	26324-706
C18	Cer 0.01μF +80-20% 100V	26383-055
C19	Cer 0.01μF +80-20% 100V	26383-055

Circuit reference	Description	M.I. code
MR1	Texas Inst. 1N916	28336-466
MR2	Texas Inst. 1N916	28336-466
MR3	Texas Inst. 1N916	28336-466
MR4	Texas Inst. 1N916	28336-466
MR5	Fairchild BAY82	28335-186
MR6	Texas Inst. 1N916	28336-466
MR7	Texas Inst. 1N916	28336-466
MR8	Texas Inst. 1N916	28336-466
MR9	Texas Inst. 1N916	28336-466
MR10	Texas Inst. 1N916	28336-466
MR11	Texas Inst. 1N916	28336-466
R1	Met 820Ω ½% ½W	24755-678
R2	Met 2.7kΩ ½% ½W	24755-692
R3	Met 2.7kΩ ½% ½W	24755-692
R4	Carb 150Ω 5% 1/8W	24231-054
R5	Carb 82Ω 10% ¼W	24341-246
R6	Carb 82Ω 10% ¼W	24341-246
R7	Carb 15kΩ 1% 1/8W	24115-150
R8	Carb 15kΩ 1% 1/8W	24115-150
R9	Met ox 1.2kΩ 5% ½W*	24552-082
R10	Met ox 1.2kΩ 5% ½W*	24552-082
R11	Carb 560Ω 1% ¼W	24133-560
R12	Carb 560Ω 1% ¼W	24133-560
R13	Met ox 180Ω 5% ¼W	24581-222
R14	Met ox 180Ω 5% ¼W	24581-222
R15	Met ox 160Ω 5% ½W*	24552-055
R16	Met ox 240Ω 5% ½W*	24552-060
R17	Carb 270Ω 1% ¼W	24133-270
R18	Carb 68Ω 10% ¼W	24341-243
R19	Carb 68Ω 10% ¼W	24341-243
R20	Carb 270Ω 1% ¼W	24133-270
R21	Met ox 270Ω 5% ¼W	24581-226
R22	Carb 56Ω 5% ¼W	24231-040
R23	Met ox 270Ω 5% ¼W	24581-226
R24	Carb 100kΩ 10% ¼W	24341-335
R25	Carb 100kΩ 10% ¼W	24341-335
R26	Carb 1.3kΩ 1% ¼W	24134-013
R27	Carb 1.3kΩ 1% ¼W	24134-013
R28	Met ox 910Ω 1% 1W	24525-138
R29	Met ox 150Ω 5% ½W*	24552-054
R30	Met ox 390Ω 5% ½W*	24552-065
R31	Met ox 430Ω 1% ½W*	24512-367
R32	Carb 390Ω 1% ¼W	24133-390
R33	Carb 390Ω 1% ¼W	24133-390
R34	Carb 10Ω 10% ¼W	24341-220
R35	Carb 10Ω 10% ¼W	24341-220
R36	Carb 47Ω 10% ¼W	24341-237
R37	Carb 6.8kΩ 10% ¼W	24341-306
RV1	Carb 1kΩ 20% ¼W	25541-219
RV2	Carb 100Ω 20% ¼W	25541-208
RV3	Carb 2.5kΩ 20% ¼W	25541-222
RV4	Carb 100Ω 20% ¼W	25541-208
RV5	Carb 2.5kΩ 20% ¼W	25541-222
RV6	Carb 1kΩ 20% ¼W	25541-219
VT1a VT1b	Marconi E2000	28452-187
VT2	Motorola 2N3227	28452-826
VT3	Motorola 2N3227	28452-826
VT4	Motorola MPS3640	28431-766
VT5	Motorola MPS3640	28431-766
VT6	Motorola MM1941	28453-856
VT7	Motorola MM1941	28453-856

A24 Channel 2 input amplifier (Fig. 7.2)

Circuit reference	Description	M.I. code
C1	Cer 0.01μF +80-20% 100V	26383-055
C2	Cer 2.5-6pF +50-10% 160V	26847-108
C3	Cer 2.5-6pF +50-10% 160V	26847-108
C4	Cer 0.001μF +80-20% 500V	26383-242
C5	Cer 0.001μF +80-20% 500V	26383-242
C6	Cer 1.5pF ±0.25pF 750V	26324-008
C7	Cer 1.5pF ±0.25pF 750V	26324-008
C8	Cer 0.01μF +80-20% 100V	26383-055
C9	Cer 0.001μF +80-20% 500V	26383-242

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C10	Cer 0.001μF +80-20% 500V	26383-242
C11	Cer 0.01μF +80-20% 100V	26383-055
C12	Cer 2.5-6pF +50-10% 16CV	26847-108
C13	Cer 0.001μF +80-20% 500V	26383-242
C14	Cer 0.001μF +80-20% 500V	26383-242
C15	Cer 4.5-20pF +70-10% 160V	26847-114
C16	Cer 6.8pF ±0.25pF 750V	26324-706
C18	Cer 0.01μF +80-20% 100V	26383-055
C19	Cer 0.01μF +80-20% 100V	16383-055
MR1	Texas Inst. 1N916	28336-466
MR2	Texas Inst. 1N916	28336-466
MR3	Texas Inst. 1N916	28336-466
MR4	Texas Inst. 1N916	28336-466
MR5	Fairchild BAY82	28335-186
MR6	Texas Inst. 1N916	28336-466
MR7	Texas Inst. 1N916	28336-466
MR8	Texas Inst. 1N916	28336-466
MR9	Texas Inst. 1N916	28336-466
MR10	Texas Inst. 1N916	28336-466
MR11	Texas Inst. 1N916	28336-466
R1	Met 820Ω ½% ½W	24755-678
R2	Met 2.7kΩ ½% ½W	24755-692
R3	Met 2.7kΩ ½% ½W	24755-692
R4	Carb 150Ω 5% 1/8W	24231-054
R5	Carb 82Ω 10% ¼W	24341-246
R6	Carb 82Ω 10% ¼W	24341-246
R7	Carb 15kΩ 1% 1/8W	24115-150
R8	Carb 15kΩ 1% 1/8W	24115-150
R9	Met ox 1.2kΩ 5% ½W*	24552-082
R10	Met ox 1.2kΩ 5% ½W*	24552-082
R11	Carb 560Ω 1% ¼W	24133-560
R12	Carb 560Ω 1% ¼W	24133-560
R13	Met ox 180Ω 5% ¼W	24581-222
R14	Met ox 180Ω 5% ¼W	24581-222
R15	Met ox 160Ω 5% ½W*	24552-055
R16	Met ox 240Ω 5% ½W*	24552-060
R17	Carb 270Ω 1% ¼W	24133-270
R18	Carb 68Ω 10% ¼W	24341-243
R19	Carb 68Ω 10% ¼W	24341-243
R20	Carb 270Ω 1% ¼W	24133-270
R21	Met ox 270Ω 5% ¼W	24581-226
R22	Carb 56Ω 5% 1/8W	24231-040
R23	Met ox 270Ω 5% ¼W	24581-226
R24	Carb 100kΩ 10% ¼W	24341-335
R25	Carb 100kΩ 10% ¼W	24341-335
R26	Carb 1.3kΩ 1% ¼W	24134-013
R27	Carb 1.3kΩ 1% ¼W	24134-013
R28	Met ox 910Ω 1% 1W	24525-138
R29	Met ox 150Ω 5% 1/8W*	24552-054
R30	Met ox 390Ω 5% ½W*	24552-065
R31	Met ox 430Ω 1% ½W*	24512-367
R32	Carb 390Ω 1% ¼W	24133-390
R33	Carb 390Ω 1% ¼W	24133-390
R34	Carb 10Ω 10% ¼W	24341-220
R35	Carb 10Ω 10% ¼W	24341-220
R36	Carb 47Ω 10% ¼W	24341-237
R37	Carb 6.8kΩ 10% ¼W	24341-306
RV1	Carb 1kΩ 20% ¼W	25541-219
RV2	Carb 100Ω 20% ¼W	25541-209
RV3	Carb 2.5kΩ 20% ¼W	25541-222
RV4	Carb 100Ω 20% ¼W	25541-209
RV5	Carb 2.5kΩ 20% ¼W	25541-222
RV6	Carb 1kΩ 20% ¼W	25541-219
VT1a, VT1b	Marconi E2000	28452-187
VT2	Motorola 2N3227	28452-826
VT3	Motorola 2N3227	28452-826
VT4	Motorola MPS3640	28431-766
VT5	Motorola MPS3640	28431-766
VT6	Motorola MM1941	28453-856
VT7	Motorola MM1941	28453-856

For symbols and abbreviations see introduction to this chapter

A25 Beam switching and trigger (Fig. 7.3)

Circuit reference	Description	M.I. code
C1	Cer 0.01μF +80-20% 100V	26383-055
C2	Cer 0.01μF +80-20% 100V	26383-055
C3	Cer 27pF 5% 500V	26324-812
C4	Cer 33pF 5% 750V	26324-822
C5	Paper 0.002μF 10% 350V	26174-129
C6	Cer 0.01μF +80-20% 100V	26383-055
C7	Cer 33pF 5% 750V	26324-822
C8	Cer 47pF 2% 750V	26324-833
C9	Paper 0.001μF 10% 500V	26174-125
C10	Plas 510pF 2% 125V	26516-416
C11	Plas 91pF ±2pF 125V	26516-231
C12	Plas 100pF ±2pF 125V	26516-241
C13	Plas 150pF 2% 125V	26516-287
C14	Plas 150pF 2% 125V	26516-287
C15	Cer 0.01μF +80-20% 100V	26383-055
C16	Cer 0.1μF +50-20% 30V	26383-031
C17	Plas 33pF ±2pF 125V	26516-127
C18	Cer 0.01μF +80-20% 100V	26383-055
C19	Cer 0.01μF +80-20% 100V	26383-055
C20	Cer 0.001μF +80-20% 500V	26383-242
C21	Cer 0.001μF +80-20% 500V	26383-242
C22	Cer 0.001μF +80-20% 500V	26383-242
C23	Cer 0.001μF +80-20% 500V	26383-242
C24	Cer 0.001μF +80-20% 500V	26383-242
C25	Cer 0.001μF +80-20% 500V	26383-242
C26	Cer 0.01μF +80-20% 100V	26383-055
C27	Cer 0.01μF +80-20% 100V	26383-055
C28	Cer 0.01μF +80-20% 100V	26383-055
C29	Cer 0.001μF +80-20% 500V	26383-242
C30	Cer 0.001μF +80-20% 500V	26383-242

Circuit reference	Description	M.I. code
MR1	Zener diode	28371-678
MR2	Texas Inst. 1S44	28357-548
MR3	Zener diode	28371-848
MR4	Texas Inst. 1S44	28357-548
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357-548
MR7	Zener diode	28371-318
MR8	Texas Inst. 1S44	28357-548
MR9	Texas Inst. 1S44	28357-548
MR10	Texas Inst. 1S44	28357-548
MR11	Texas Inst. 1S44	28357-548
MR12	Texas Inst. 1S44	28357-548
MR13	Texas Inst. 1S44	28357-548
MR14	Zener diode	28371-758
MR15	Texas Inst. 1S44	28357-548
MR16	Texas Inst. 1S44	28357-548
MR17	Texas Inst. 1S44	28357-548
MR18	Texas Inst. 1S44	28357-548
MR19	Texas Inst. 1S44	28357-548
MR20	Texas Inst. 1S44	28357-548
MR21	Texas Inst. 1S44	28357-548
MR22	Texas Inst. 1S44	28357-548
MR23	Texas Inst. 1S44	28357-548
MR24	Texas Inst. 1S44	28357-548
MR25	Texas Inst. 1S44	28357-548
MR26	Texas Inst. 1S44	28357-548
MR27	Texas Inst. 1N916	28336-466
MR28	Texas Inst. 1N916	28336-466
MR29	Texas Inst. 1N916	28336-466
MR30	Texas Inst. 1N916	28336-466
MR31	Texas Inst. 1N916	28336-466
MR32	Texas Inst. 1N916	28336-466
MR33	Texas Inst. 1N916	28336-466
MR34	Texas Inst. 1N916	28336-466
MR35	Fairchild NAY82	28335-186
MR36	Fairchild BAY82	28335-186

Circuit reference	Description	M.I. code
R1	Met ox 56Ω 5% ¼W	24581-210
R2	Met ox 330Ω 5% ¼W	24581-228
R3	Carb 47Ω 10% ¼W	24341-237
R4	Carb 1.5kΩ 10% ¼W	24341-284
R5	Met ox 6.2kΩ 5% ½W*	24552-082
R6	Carb 47Ω 10% ¼W	24341-237
R7	Carb 47Ω 10% ¼W	24341-237

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code	Circuit reference	Description	M.I. code
R8	Met ox 1.2kΩ 5% ¼W*	24552-082	R48	Carb 100Ω 10% ¼W	24341-250
R9	Met ox 2kΩ 5% ¼W	24581-247	R49	Carb 100Ω 10% ¼W	24341-250
R10	Carb 2.2kΩ 10% ¼W	24341-288	R50	Met ox 560Ω 1% ½W*	24512-372
R11	Met ox 2kΩ 5% ½W*	24552-087	R51	Met ox 560Ω 1% ½W*	24512-372
R12	Met ox 2.4kΩ 5% ¼W	24581-249	R52	Met ox 100Ω 1% ½W*	24512-350
R13	Met ox 160Ω 5% ½W*	24552-055	R53	Met ox 110Ω 1% ¼W	24581-217
R14	Met ox 2kΩ 5% ¼W	24581-247	R54	Met ox 100Ω 5% ½W*	24552-050
R15	Met ox 1kΩ 5% 1W	24585-126	R55	Carb 47Ω 10% ¼W	24341-237
R16	Met ox 330Ω 5% ¼W	24581-228	R56	Carb 47Ω 10% ¼W	24341-237
R17	Met ox 3.3kΩ 5% ¼W	24581-252	R57	Met ox 130Ω 1% ¼W	24522-253
R18	Carb 5.6kΩ 10% ¼W	24341-303	R58	Met ox 130Ω 1% ¼W	24522-253
R19	Met ox 160Ω 5% ½W*	24552-055	R59	Carb 22Ω 10% ¼W	24341-228
R20	Met ox 3.3kΩ 5% ¼W	24581-252	R60	Carb 22Ω 10% ¼W	24341-228
R21	Carb 47Ω 10% ¼W	24341-237	R62	Carb 1.5kΩ 10% ¼W	24341-284
R22	Carb 1.8kΩ 10% ¼W	24341-286	R63	Carb 47Ω 10% ¼W	24341-237
R23	Carb 1kΩ 10% ¼W	24341-280	R64	Carb 47Ω 10% ¼W	24341-237
R24	Carb 3.3kΩ 10% ¼W	24341-294	R65	Met ox 2.4kΩ 5% ¼W	24581-249
R25	Carb 15Ω 10% ¼W	24341-224	R66	Met ox 2.4kΩ 5% ¼W	24581-249
R26	Met ox 1kΩ 5% 1W	24585-126	R67	Met ox 2.4kΩ 5% ¼W	24581-249
R27	Met ox 330Ω 5% ¼W	24581-228	R68	Met ox 2.4kΩ 5% ¼W	24581-249
R28	Carb 47Ω 10% ¼W	24341-237	R69	Met ox 3.9kΩ 5% ¼W	24581-254
R29	Carb 47Ω 10% ¼W	24341-237	R70	Met ox 3.9kΩ 5% ¼W	24581-254
R30	Met ox 2.4kΩ 5% ¼W	24581-249	R71	Met ox 3.9kΩ 5% ¼W	24581-254
R31	Met ox 160Ω 5% ½W*	24552-055	R72	Met ox 3.9kΩ 5% ¼W	24581-254
R32	Met ox 330Ω 5% ¼W	24581-228	R73	Carb 62Ω 1% 1/8W	24112-620
R33	Met ox 47Ω 5% ¼W	24581-208	R74	Carb 62Ω 1% 1/8W	24112-620
R34	Carb 100Ω 10% ¼W	24341-250	R75	Met ox 120Ω 5% ¼W	24581-218
R35	Carb 1.5kΩ 10% ¼W	24341-284	R76	Met ox 120Ω 5% ¼W	24581-218
R36	Met ox 1kΩ 5% ¼W	24581-240	R77	Carb 62Ω 1% 1/8W	24112-620
R37	Met ox 100Ω 10% ¼W*	24522-250	R78	Carb 62Ω 1% 1/8W	24112-620
R38	Carb 56Ω 10% ¼W	24341-240	R79	Met ox 820Ω 5% ½W*	24552-078
R39	Met ox 560Ω 5% ¼W	24581-234	R80	Met ox 820Ω 5% ½W*	24552-078
R40	Met ox 560Ω 5% ¼W	24581-234	R81	Met ox 360Ω 5% ¼W	24581-229
R41	Carb 12kΩ 10% ¼W	24341-312	R82	Met ox 240Ω 5% ¼W	24581-225
R42	Carb 220Ω 10% ¼W	24341-258	R83	Met ox 2.4kΩ 5% ¼W	24581-249
R43	Carb 220Ω 10% ¼W	24341-258	R84	Met ox 2.4kΩ 5% ¼W	24581-249
R44	Met ox 560Ω 1% ½W*	24512-372	R85	Met ox 820Ω 5% ½W*	24552-078
R45	Met ox 560Ω 1% ½W*	24512-372	R86	Met ox 820Ω 5% ½W*	24552-078
R46	Carb 100Ω 10% ¼W	24341-250	R87	Met ox 100Ω 5% ¼W	24581-216
R47	Carb 100Ω 10% ¼W	24341-250	R88	Carb 47Ω 10% ¼W	24341-237

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R89	Carb 47Ω 10% ¼W	24341-237
R90	Met ox 820Ω 5% ¼W	24581-238
R91	Met ox 270Ω 5% ¼W	24581-226
R92	Met ox 820Ω 5% ¼W	24581-238
R93	Met ox 1.8kΩ 5% ¼W	24581-246
R94	Met ox 1.8kΩ 5% ¼W	24581-246
R95	Met ox 4.3kΩ 1% ½W*	24512-397
R96	Met ox 4.3kΩ 1% ½W*	24512-397
R97	Met ox 270Ω 5% ¼W	24581-226
R98	Met ox 220Ω 5% ¼W	24581-224
R99	Met ox 220Ω 5% ¼W	24581-224
R100	Met ox 220Ω 5% ¼W	24581-224
R101	Met ox 220Ω 5% ¼W	24581-224
R102	Met ox 100Ω 5% ½W*	24552-050
R103	Met ox 360Ω 5% ¼W	24581-229
R104	Met ox 360Ω 5% ¼W	24581-229
R105	Met ox 1.2kΩ 1% ½W*	24512-382
R106	Met ox 160Ω 1% ½W*	24512-355
R107	Met ox 160Ω 1% ½W*	24512-355
R108	Met ox 1.2kΩ 1% ½W*	24512-382
R109	Met ox 430Ω 5% ½W*	24552-067
R110	Carb 3.6kΩ 1% ¼W	24134-360
R111	Carb 3.6kΩ 1% ¼W	24134-360
R112	Met ox 18kΩ 5% ¼W	24581-270
R113	Met ox 18kΩ 5% ¼W	24581-270
R114	Carb 620Ω 1% ¼W	24133-620
R115	Carb 620Ω 1% ¼W	24133-620
R116	Met ox 18kΩ 5% ¼W	24581-270
R117	Met ox 18kΩ 5% ¼W	24581-270
R118	Met ox 180Ω 5% ¼W	24581-222
R119	Met ox 180Ω 5% ¼W	24581-222
R120	Met ox 430Ω 1% ½W*	24512-367
R121	Carb 75Ω 1% ¼W	24132-750
R122	Carb 75Ω 1% ¼W	24132-750
R123	Met ox 470Ω 5% ¼W	24581-232
R124	Carb 100Ω 10% ¼W	24341-250
R125	Met ox 82Ω 5% ¼W	24581-214
R126	Met ox 180Ω 5% ½W*	24552-056
R127	Met ox 180Ω 5% ½W*	24552-056
R128	Met ox 180Ω 5% ½W*	24552-056
R129	Met ox 360Ω 5% ¼W	24581-229
R130	Met ox 360Ω 5% ¼W	24581-229
RV1	Carb 1kΩ 20% ¼W	25541-319
RV2	Carb 5kΩ 20% ¼W	25541-327
RV3	Carb 5kΩ 20% ¼W	25541-327
RV4	Carb 5kΩ 20% ¼W	25541-327
RV5	Carb 5kΩ 20% ¼W	25541-327
RV6	Carb 1kΩ 20% ¼W	25541-319
RV7	Carb 1kΩ 20% ¼W	25541-319
RV8	Carb 5kΩ 20% ¼W	25541-327
RV9	Carb 1kΩ 20% ¼W	25541-319
SA	Bandwidth switch (situated internally)	23467-251
T1	Transformer	44232-009
VT1	General purpose n-p-n	28452-787
VT2	General purpose n-p-n	28452-197
VT3	General purpose n-p-n	28452-197
VT4	General purpose n-p-n	28452-197
VT5	General purpose n-p-n	28452-787
VT6	General purpose n-p-n	28452-787
VT7	General purpose n-p-n	28452-787
VT8	General purpose n-p-n	28452-197
VT9	Motorola MPS3640	28431-766
VT10	Motorola MPS3640	28431-766
VT11	Motorola 2N3906	28434-856
VT12	Motorola 2N3906	28434-856
VT13	Motorola MPS3640	28431-766
VT14	Motorola MPS3640	28431-766
VT15	Motorola MPS3640	28431-766
VT16	Motorola MPS3640	28431-766
VT17	Motorola MPS3640	28431-766
VT18	Motorola MPS3640	28431-766
VT19	Motorola MPS3563	28451-686
VT20	Motorola MPS3563	28451-686
VT21	Motorola MPS3640	28431-766

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
VT22	Motorola MPS3640	28431-766
VT23	Motorola MPS3563	28451-686
VT24	Motorola MPS3563	28451-686
VT25	Motorola MPS3640	28431-766
VT26	Motorola MPS3640	28431-766
VT27	Motorola 2N3227	28452-826
VT28	Motorola 2N3227	28452-826

A26 Main amplifier (Fig. 7.4)

C1	Cer 2-3.5pF +50-10% 160V	26847-104
C2	Cer 4.5-20pF +70-10% 160V	26847-114
C3	Plas 56pF ±2pF 125V	26516-181
C4	Cer 0.001μF +80-20% 500V	26383-242
C5	Cer 0.001μF +80-20% 500V	26383-242
C6	Cer 0.1μF +50-20% 30V	26383-031
C7	Cer 0.01μF +80-20% 100V	26383-055
C8	Cer 4-20pF +50-10% 250V	26847-243
C9	Plas 18pF ±2pF 125V	26516-028
C10	Cer 0.1μF +50-20% 30V	26383-031
C11	Cer 0.1μF +50-20% 30V	26383-031
C12	Cer 0.1μF +50-20% 30V	26383-031
C13	Cer 3.5-10pF +50-10% 160V	26847-110
C14	Cer 0.1μF +50-20% 30V	26383-031
C15	Plas 270pF 2% 125V	26516-350
C16	Cer 0.001μF +80-20% 500V	26383-242
C17	Cer 0.001μF +80-20% 500V	26383-242
C18	Cer 0.01μF +80-20% 100V	26383-055
C19	Cer 0.01μF +80-20% 500V	26383-392
C20	Cer 0.01μF +80-20% 100V	26383-055
C21	Cer 0.01μF +80-20% 100V	26383-055
C22	Cer 0.01μF +80-20% 100V	26383-055
C23	Plas 0.001μF 2% 125V	26516-481
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Texas Inst. 1S44	28357-548
MR5	Zener diode	28371-440
MR6	Zener diode	28371-440
MR7	Zener diode	28371-248
R1	Carb 100Ω 1% ¼W	24133-100
R2	Carb 100Ω 1% ¼W	24133-100
R3	Carb 47Ω 10% ¼W	24341-237
R4	Carb 47Ω 10% ¼W	24341-237
R5	Carb 130Ω 1% 1/8W	24113-130
R6	Met ox 36Ω 5% ½W*	24552-034
R7	Met ox 68Ω 5% ¼W	24581-212
R8	Met ox 68Ω 5% ¼W	24581-212
R9	Carb 390Ω 10% ¼W	24341-265
R10	Carb 390Ω 10% ¼W	24341-265
R11	Carb 100Ω 10% ¼W	24341-250
R12	Carb 12kΩ 10% ¼W	24341-312
R13	Carb 12kΩ 10% ¼W	24341-312
R14	Met ox 8.2kΩ 5% ¼W	24581-262
R15	Met ox 2.2kΩ 5% ¼W	24581-248
R16	Met ox 2.2kΩ 5% ¼W	24581-248
R17	Met ox 8.2kΩ 5% ¼W	24581-262
R18	Carb 1.1kΩ 1% ¼W	24134-110
R19	Carb 1.1kΩ 1% ¼W	24134-110
R20	Met ox 4.3kΩ 5% ½W*	24552-097
R21	Met ox 1.6kΩ 5% 1W	24585-131
R22	Carb 150Ω 1% ¼W	24133-150
R23	Carb 150Ω 1% ¼W	24133-150
R24	Carb 22Ω 10% ¼W	24341-228
R25	Carb 22Ω 10% ¼W	24341-228
R26	Carb 62Ω 5% 1/8W	24231-042
R27	Met ox 51Ω 1% ½W*	24512-339
R28	Met ox 1.3kΩ 1% 1W	24525-140
R29	Met ox 1.3kΩ 1% 1W	24525-140
R30	Met ox 100Ω 1% 2W	24527-250
R31	Carb 100Ω 1% ¼W	24133-100
R32	Carb 100Ω 1% ¼W	24133-100
R33	Carb 22Ω 10% ¼W	24341-228
R34	Carb 22Ω 10% ¼W	24341-228

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R35	Met ox 51Ω 1% ½W*	24512-339
R36	Met ox 68Ω 5% 1W	24585-109
R37	Met ox 68Ω 5% 1W	24585-109
R38	Met ox 20kΩ 5% ¼W	24581-271
R39	Met ox 390Ω 1% 2W	24527-265
R40	Met ox 390Ω 1% 2W	24527-265
R41	Met ox 56Ω 1% 1W	24525-115
R42	Carb 22kΩ 10% ¼W	24341-318
R43	Carb 82Ω 10% ¼W	24341-246
RV1	Carb 1kΩ 20% ¼W	24451-219
RV2	Carb 25kΩ 20% ¼W	24451-222
RV3	Carb 500Ω 10% ¼W	24451-269
RV4	Carb 100Ω 20% ¼W	24451-208
RV5	Carb 10kΩ 20% ¼W	24451-233
VT1	Motorola MPS3563	28451-686
VT2	Motorola MPS3563	28451-686
VT3	Ferranti ZTX320	28452-101
VT4	Ferranti ZTX320	28452-101
VT5	Ferranti ZTX313	28452-201
VT6	Ferranti ZTX313	28452-201
VT7	R.C.A. 2N5109	28454-797
VT8	R.C.A. 2N5109	28454-797
X1	Ferrite bead	23635-833
X2	Ferrite bead	23635-833
X3	Ferrite bead	23635-833
X4	Ferrite bead	23635-833
X5	Ferrite bead	23635-833
X6	Ferrite bead	23635-833
X7	Ferrite bead	23635-833
X8	Ferrite bead	23635-833
X9	Ferrite bead	23635-833

A27 Probe power supply

Circuit reference	Description	M.I. code
C1	Elec 100µF +100-20% 25V	26417-158
C2	Elec 50µF +100-20% 25V	26417-152
C3	Elec 50µF +100-20% 25V	26417-152
R1	Carb 100kΩ 10% ¼W	24341-335
R2	Met ox 910Ω 5% ¼W	24581-239
R3	Carb 100Ω 10% ¼W	24341-250
R4	Carb 100Ω 10% ¼W	24341-250
R5	Met ox 330Ω 5% ¼W	24581-228
R6	Carb 100kΩ 10% ¼W	24341-335
R7	Met ox 910Ω 10% ¼W	24581-239
R8	Carb 100Ω 10% ¼W	24341-250
R9	Carb 100Ω 10% ¼W	24341-250
R10	Met ox 330Ω 5% ¼W	24581-228
R11	Carb 100kΩ 10% ¼W	24341-335
R12	Carb 100kΩ 10% ¼W	24341-335
R13	Met ox 300Ω 5% ½W*	24552-062
R14	Met ox 1.3kΩ 5% ½W	24552-083
R15	Met ox 1.3kΩ 5% ½W	24552-083
R16	Met ox 300Ω 5% ½W	24552-062
R17	Carb 220Ω 10% ½W	24342-058
R18	Carb 180Ω 10% ½W	24342-056
VT1	General purpose p-n-p	28433-487
VT2	General purpose n-p-n	28452-787
VT3	Mullard BFY51	28455-827
VT4	Mullard BFX88	28434-877

For symbols and abbreviations see introduction to this chapter

Chapter 7

Circuit diagrams

Circuit notes

COMPONENT VALUES

Resistors: No suffix = ohms, k = kilohms, M = megohms.
Capacitors: No suffix = microfarads, p = picofarads.
† value selected during test, nominal value shown.

VOLTAGES

Shown in italics adjacent to the point to which the measurement refers. Vd indicates voltage which is decoupled from source voltage.

SYMBOLS

arrow indicates clockwise rotation of knob.

etc., external front panel marking.

tag on printed board.

test point on printed board.

or A23 unit identification number.

WAVEFORM DIAGRAMS

The waveform diagrams or oscillograms shown on Fig. 7.3 were taken using a TF 2210 as the monitor oscilloscope, the sweep speed and gain of which is indicated with each diagram. The triggering conditions of the monitor oscilloscope is detailed in the oscillogram summary (on the stub of Fig. 7.3). Where the oscilloscope is externally triggered the trigger is taken from the GATE OUT socket on the appropriate sweep unit. To obtain similar waveforms, set your oscillocope controls as detailed in Sect. 4.5 of the TF 2210 manual. Any variation from these positions is indicated with the particular oscillogram.

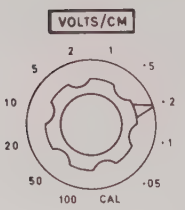
CIRCUIT REFERENCES

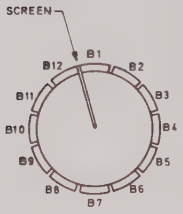
These are, where there is a risk of ambiguity, given with the unit number.

SWITCHES

Rotary switches are drawn schematically.

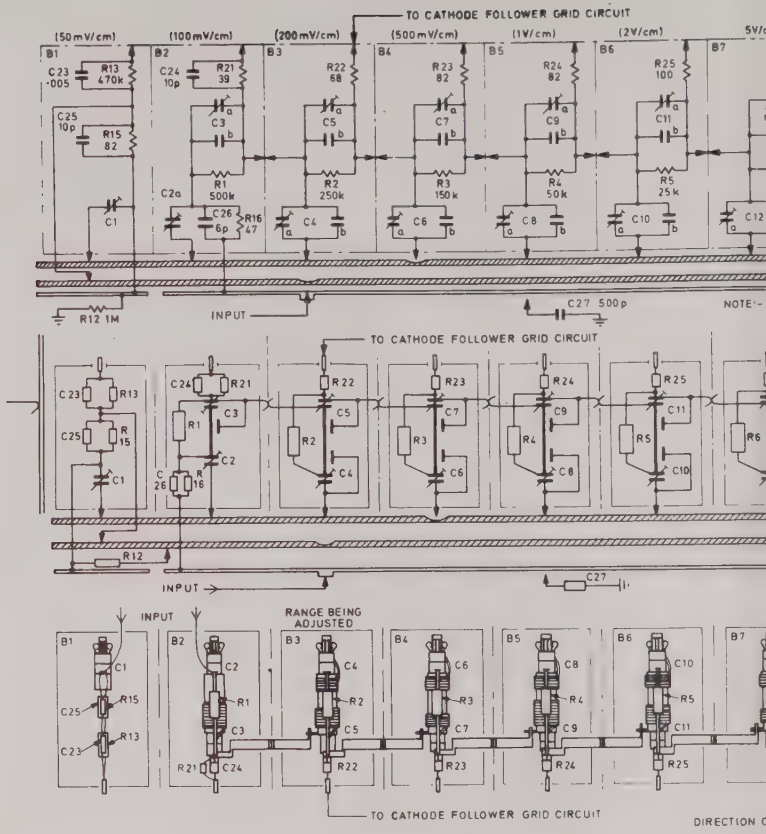
1F = 1st section (front panel) front.
1B = 1st section, back.
2F = 2nd section, front.
etc.



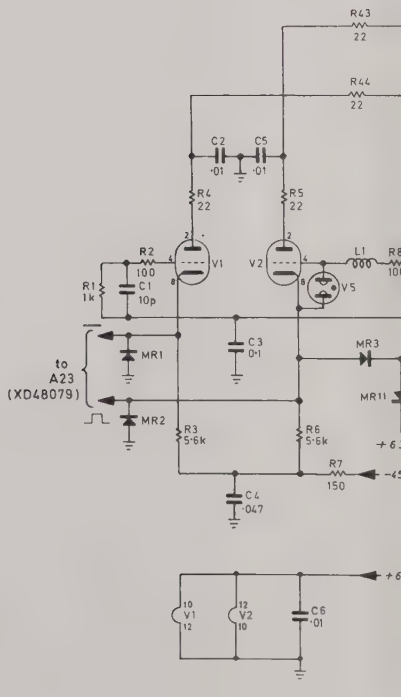


ORIENTATION OF SECTORS
WHEN VIEWED FROM KNOB END.

A21



A22



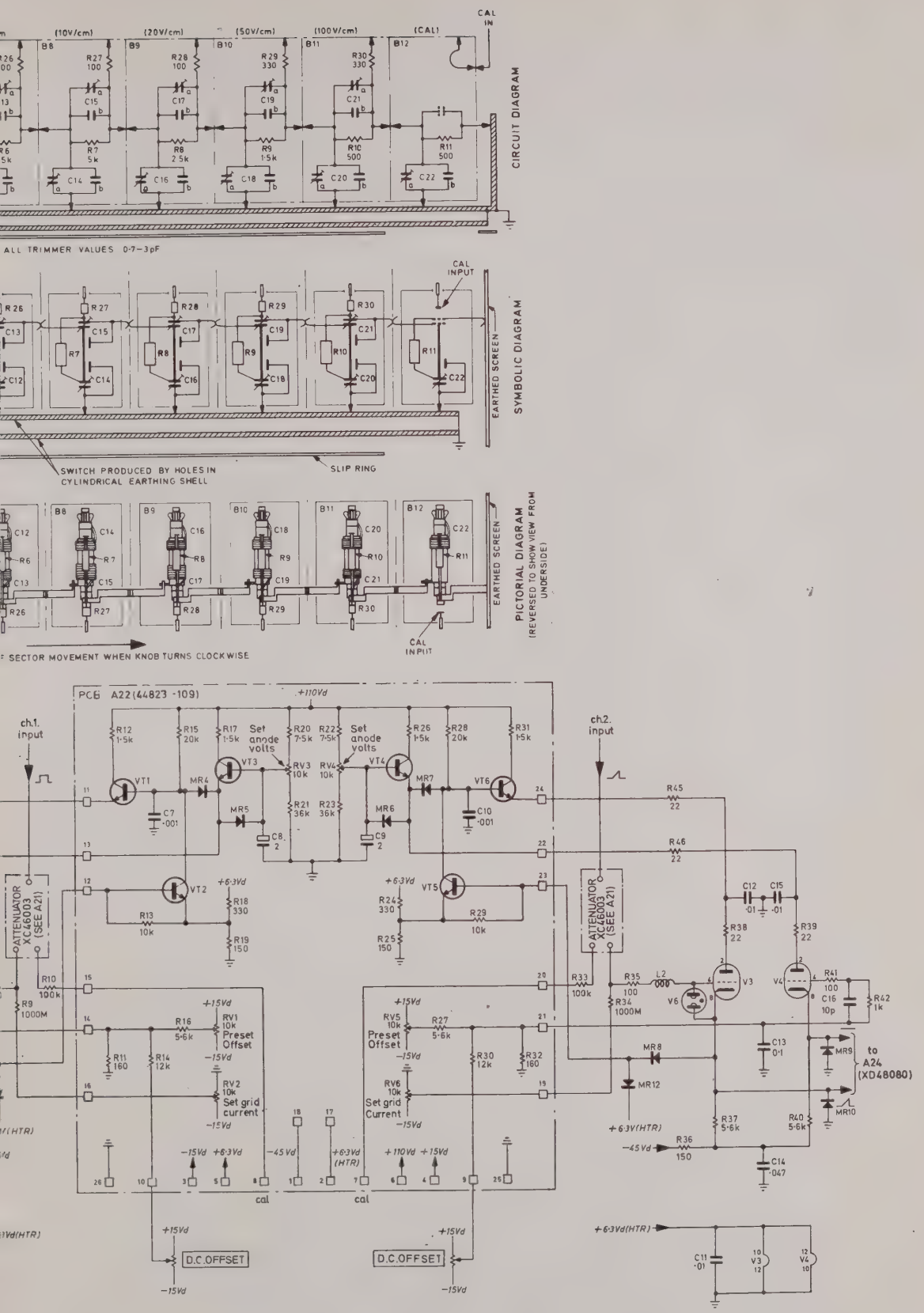
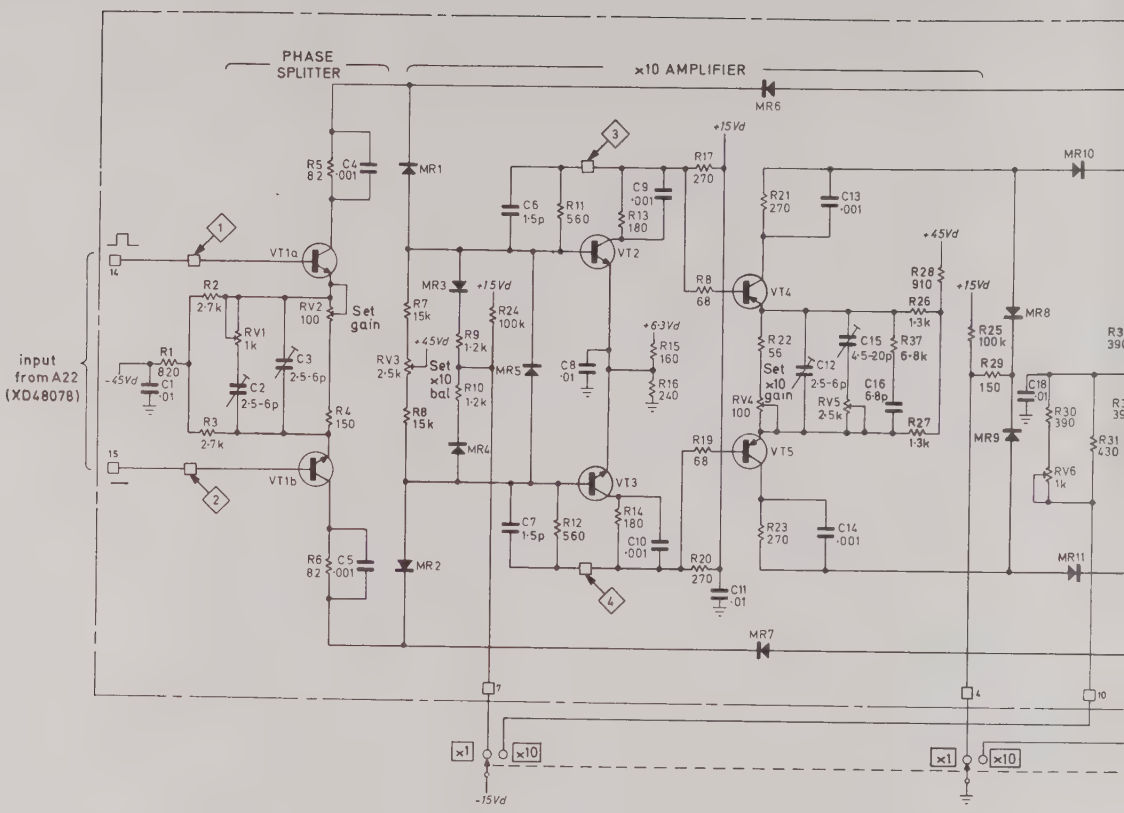
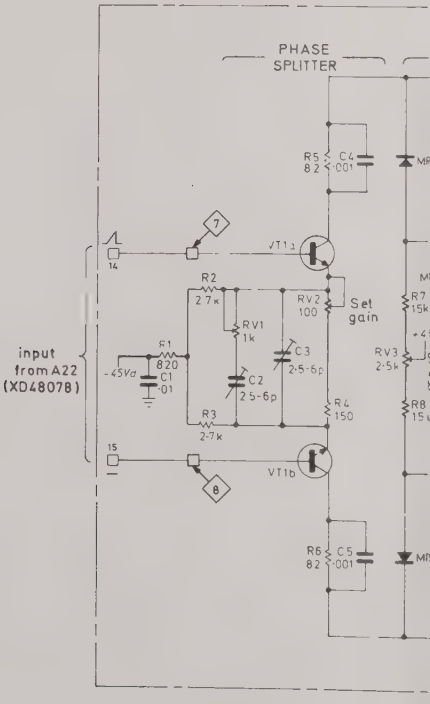


Fig. 7.1 Input cathode followers


PHASE SPLITTER
×10 AMPLIFIER
input from A22 (XD48078)
Set gain
Set ×10 bal
Set ×10 gain
VT1a
VT1b
VT2
VT3
VT4
VT5
MR1
MR2
MR3
MR4
MR5
MR6
MR7
MR8
MR9
MR10
MR11
+15Vd
-15Vd
+45Vd
-45Vd
+6·3Vd
×1
×10


PHASE SPLITTER
input from A22 (XD48078)
Set gain
VT1a
VT1b
-45Vd

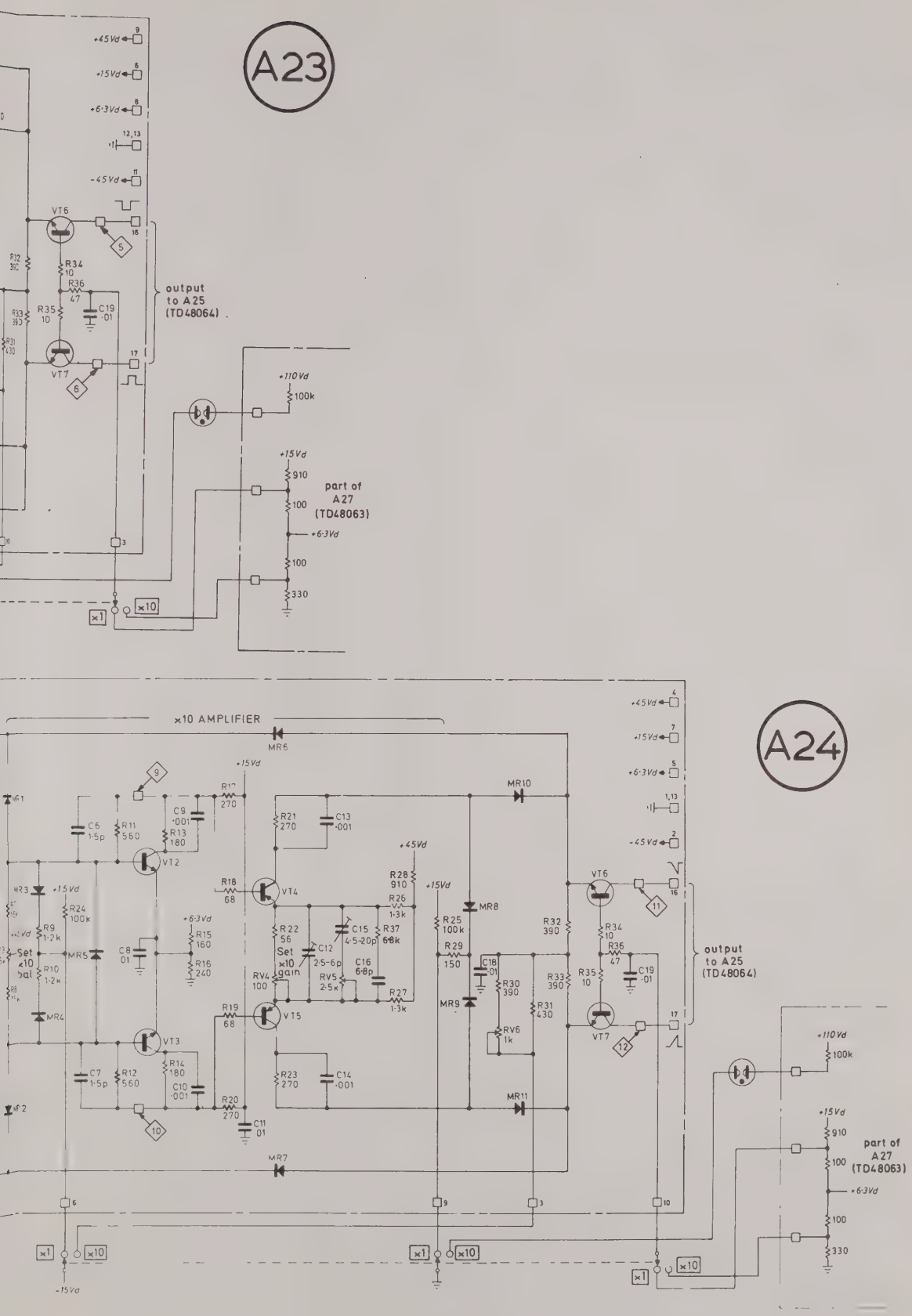
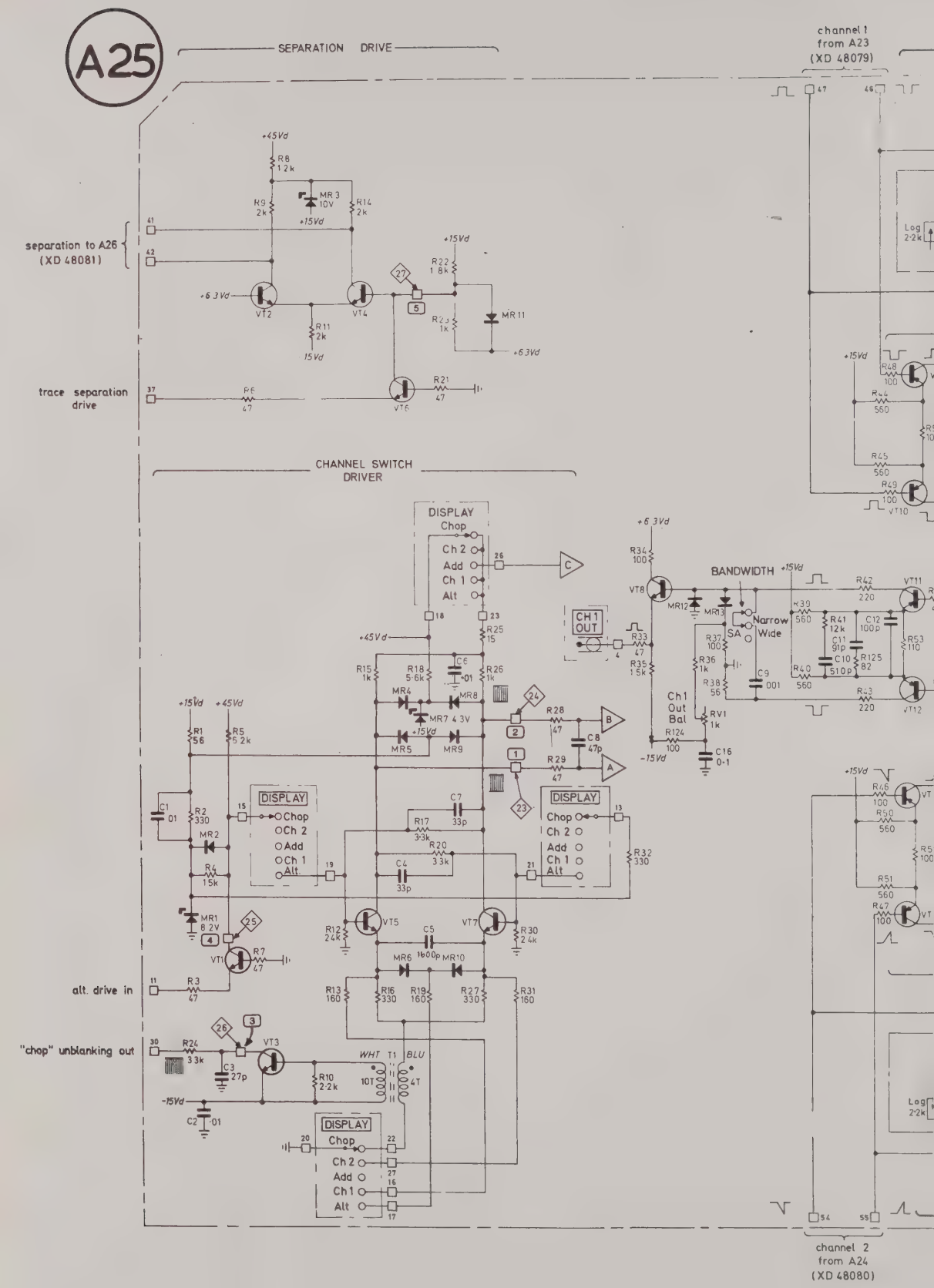


Fig. 7.2 Channel 1 input amplifier and channel 2 input amplifier


A25
SEPARATION DRIVE
channel 1 from A23 (XD 48079)
separation to A26 (XD 48081)
trace separation drive
CHANNEL SWITCH DRIVER
DISPLAY
Chop
Ch 2
Add
Ch 1
Alt
BANDWIDTH
Narrow
Wide
SA
CH1 OUT
Ch1 Out Bal
alt. drive in
"chop" unblanking out
channel 2 from A24 (XD 48080)

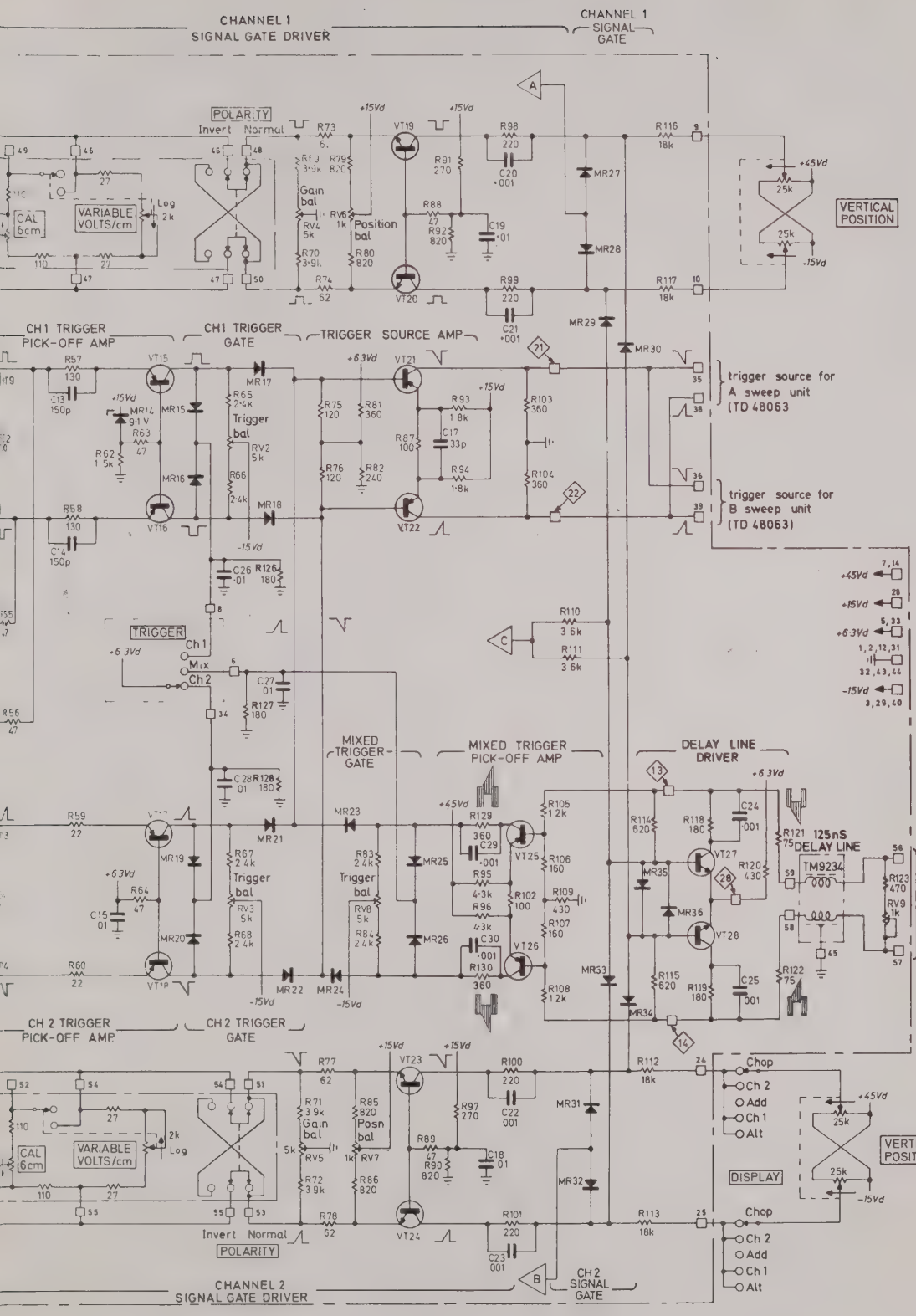
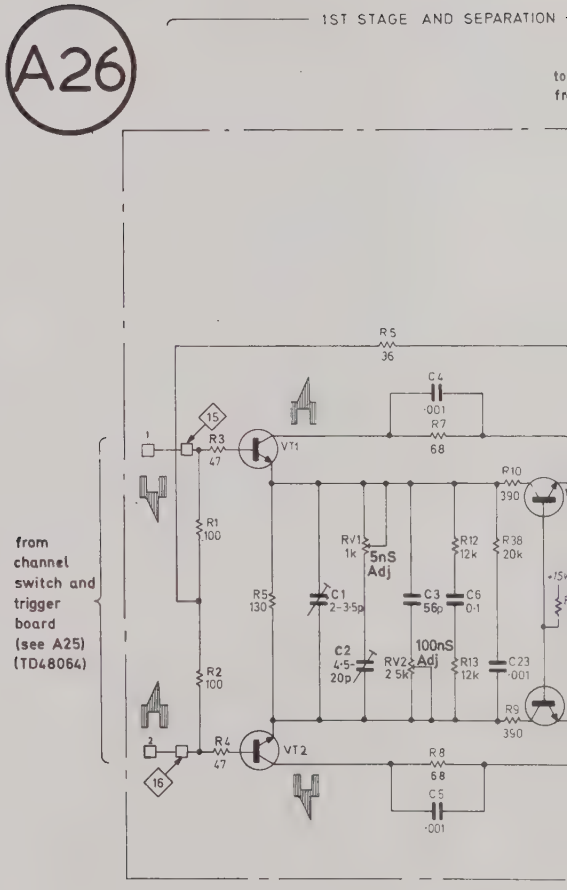


Fig. 7.3 Beam switch and trigger


A26
1ST STAGE AND SEPARATION
to
fr
from channel switch and trigger board (see A25) (TD48064)
R5 36
C4 ·001
R7 68
15
R3 47
VT1
R10 390
R1 100
RV1 1k
5nS Adj
R12 12k
R38 20k
R5 130
C1 2-3·5p
C3 56p
C6 0·1
C2 4·5-20p
RV2 2·5k
100nS Adj
R13 12k
C23 ·001
R2 100
R9 390
R4 47
VT2
16
R8 68
C5 ·001

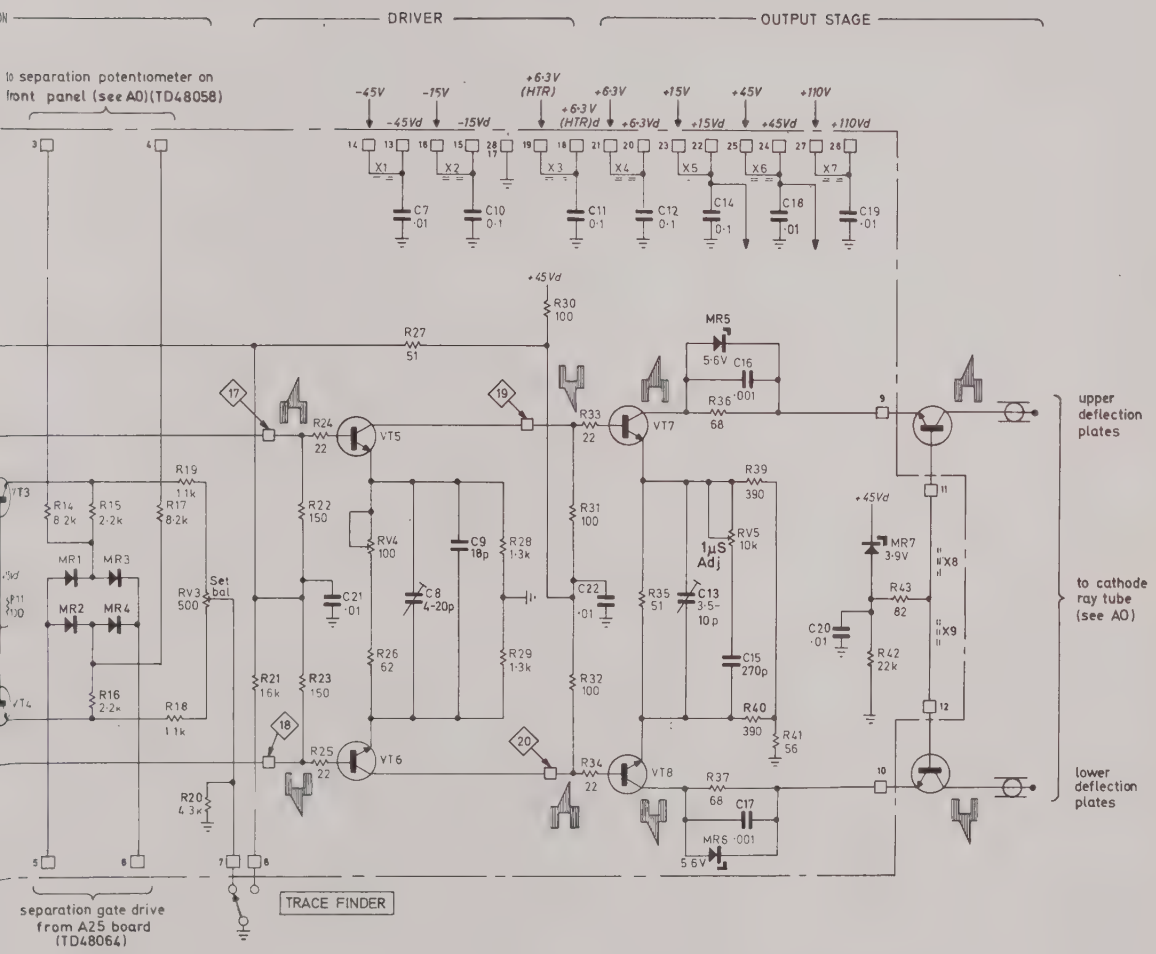
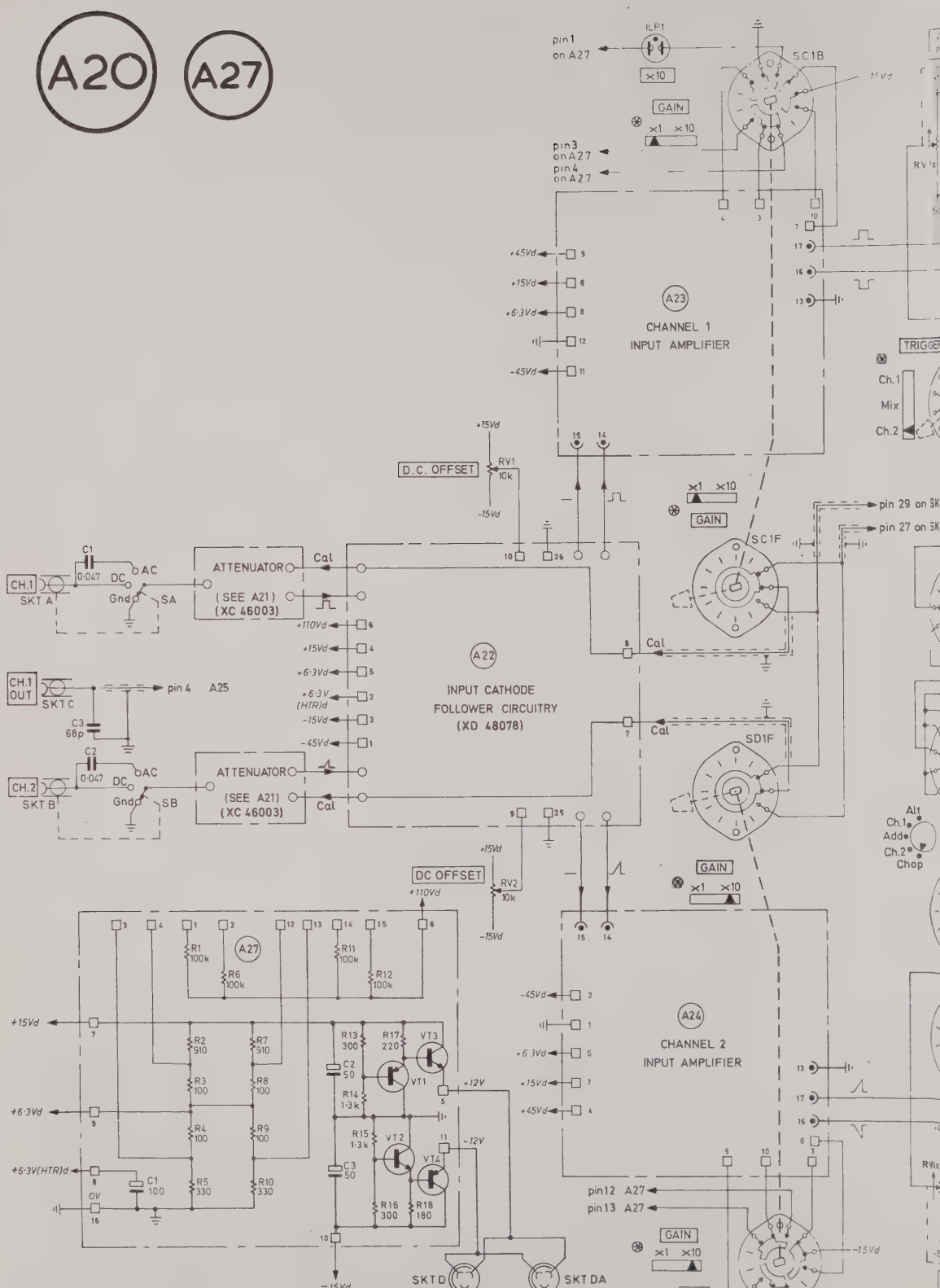
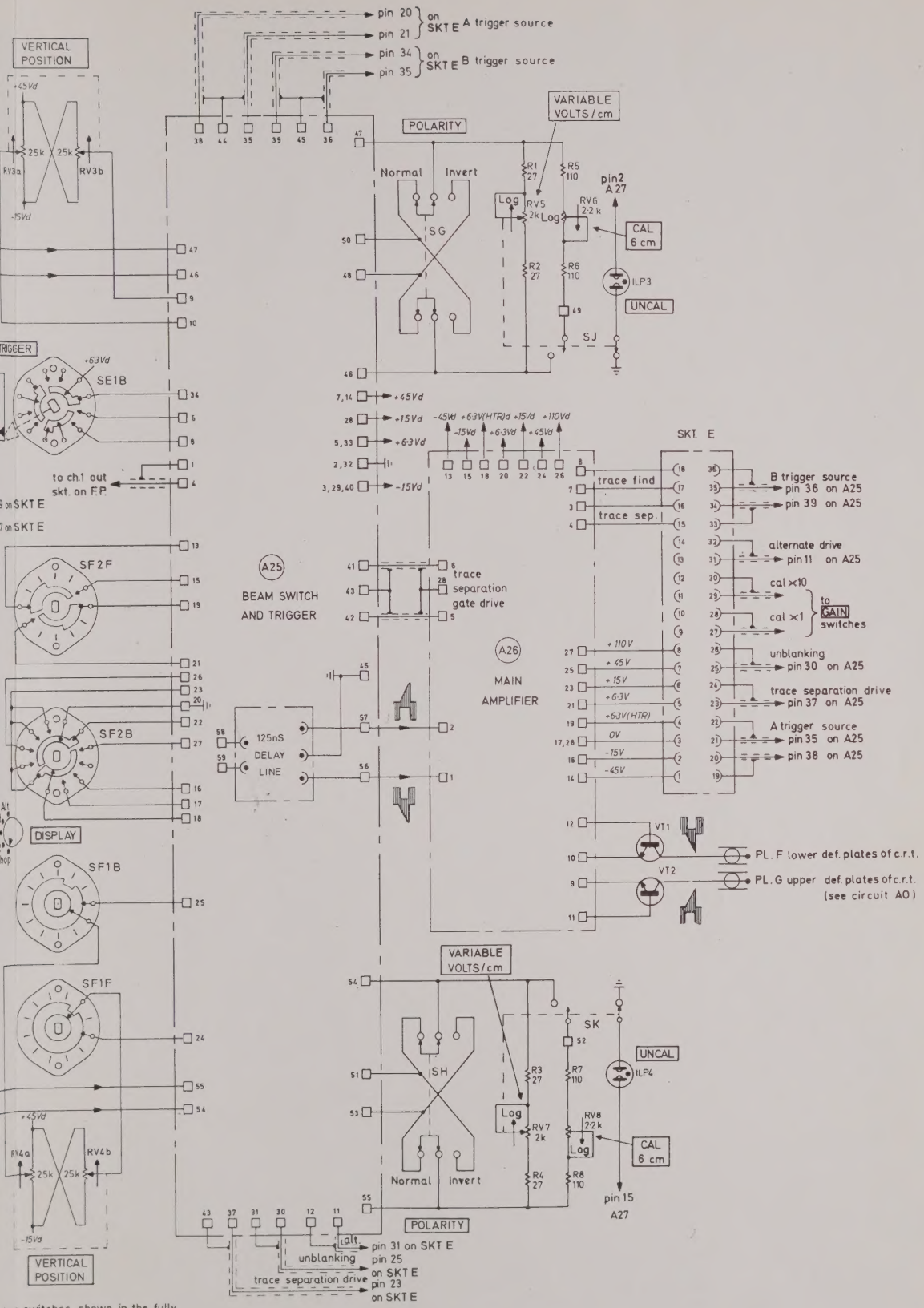


Fig. 7.4 Main amplifier

A20 A27


A23
CHANNEL 1
INPUT AMPLIFIER
A22
INPUT CATHODE
FOLLOWER CIRCUITRY
(XD 48078)
A24
CHANNEL 2
INPUT AMPLIFIER
A27
SC1B
SC1F
SD1F
SD1B
ATTENUATOR
(SEE A21)
(XC 46003)
D.C. OFFSET
DC OFFSET
GAIN
PROBE POWER
SKT D
SKT DA
pin 1 on A27
pin 3 on A27
pin 4 on A27
pin 4 A25
pin 29 on SK
pin 27 on SK
pin12 A27
pin13 A27
pin14 A27
Ch.1
Mix
Ch.2
Alt
Add
Chop
these are lever s
counter- clockwis
indexing mechan



lever switches shown in the fully clockwise position as viewed through mechanism.

Fig. 7.5 Vertical amplifier interconnection

TM 9722

MARCONI INSTRUMENTS LIMITED
ST. ALBANS, HERTS., ENGLAND

SERVICE DIVISION	**HEDLEY ROAD, ST. ALBANS, HERTS.** *Telephone: St. Albans 50731* (Ansafone)
HOME and EXPORT SALES OFFICES	**LONGACRES, ST. ALBANS, HERTS.** *Telephone: St. Albans 59292* *Telegrams: Measurtest, St. Albans* *Telex: 23350*
U.S.A.	**MARCONI INSTRUMENTS DIVISION OF ENGLISH ELECTRIC CORP., 111 CEDAR LANE, ENGLEWOOD, NEW JERSEY 07631** *Telephone: 201 567-0607*
BUNDESREPUBLIK DEUTSCHLAND	**MARCONI MESSTECHNIK GMBH, 8 MÜNCHEN-SOLLN, WOLFRATSHAUSER STRASSE 243** *Telefon: 79 78 50* *Fernschreiber: 05/24642*
FRANCE	**MARCONI INSTRUMENTS, SUCCURSALE DE FRANCE, 40 RUE DE L'AQUEDUC, PARIS Xe** *Téléphone: Paris 607 71-12 71-13*

WORLD-WIDE REPRESENTATION

MP MASTER

MA23736

Printed in England by The Campfield Press, St. Albans